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ART. LVI.—*On Jupiter and its Satellites;* by MARIA MITCHELL, Professor of Astronomy in Vassar College. (With a plate.)

THE observations referred to in the following notes were made at a time when the mechanism of the instrument in use was receiving improvements, and the records are therefore those of eye estimates and not of accurate measurements. They do not, however, rest wholly on my own impressions. Separate drawings and estimates were made in several cases by three of my students, Misses Abbot, Glover, and Mead, and my own were checked by theirs.

The characteristics of the phenomena seen on Jupiter's disc in the Fall of 1870 and the Winter of 1870–71 differed from those of the preceding year. The rosy tinge of the equatorial belt was less marked; the dark spots on the same belt were less decided, and the white spots more numerous. In the notes of Jan. 9, 1870, I use the expression "very rosy" in describing the upper edge of the broad belt; words which I could not use in regard to the color, at any time of observation since that date.

The instrument used was the large Equatorial telescope, the object-glass of which is 12½ inches in diameter.

The oval marking given in fig. 1 was seen Jan. 19, 1870. It is without doubt the same seen by Prof. Mayer at an earlier date.

It is at least a singular coincidence, that a group of small spots on the sun, arranging themselves in the same figure, is recorded on Jan. 22. I record on June 18, 1870, a rosy tinge on the extreme northern edge of Saturn's ring; the night being remarkably good.

Nov. 1, 1870.—Two shadows and one satellite were seen at once on Jupiter's disc. The satellite, which was the first, was faint, brown, and ill defined, when first seen; near the center of the planet, its shape was oval. A large spot could be seen on the fourth satellite.

Nov. 10, 1870.—The narrow southern dark belt has a violet tinge.

Nov. 16, 1870.—A short and broad violet marking was seen near the northern border.

Nov. 28, 1870.—The broad equatorial belt could be seen out to the following edge. There were three large white spots upon it. The third satellite was warmer in tint than the other three.

Dec. 3.—The broad belt was seen again, quite out to the following limb. The first satellite was seen on the planet near the preceding limb, of dazzling whiteness, resembling the polar regions of Mars. White spots were noticed on the broad belt. The fourth satellite seemed to have a halo around it.

Dec. 10, 1870.—I began early to watch for the entrance of the first satellite and its shadow. The planet was low and the air full of tremor. I lost the satellite at once, when it entered upon the planet, and did not see it until 8 P. M., when I found it near the center of the disc. It seemed to be round and was dusky in color. Only twelve minutes later, this round figure had enlarged and become an irregular oval figure, stretching into the broad equatorial belt; it was then very distinct. As the shadow and satellite were thrown upon the planet nearly at the same time, it is probable that they were seen together, but there was no distinction of color. It seemed as large as the third satellite plus about its third. The whole shrunk suddenly, and then disappeared a few minutes after 9 P. M., and at $9^h\ 32^m$ P. M. the satellite reappeared, still on the planet, round and very white. At $10^h\ 5^m$ the broad dark equatorial belt was seen out to the following edge. I have given the changes of the first satellite in figs. 3 and 4. No inequality of brightness could be detected in the bright belt along which the course of the satellite lay.

Dec. 16, 1870.—The noticeable peculiarities are, the continuance of the dark equatorial belt quite out to the limb of the planet, both preceding and following, but more strongly in the latter case, and the unequal brightness of the southern bright belt, presenting in a coarse way something of the appearance of the sun's disc. The third satellite was brighter at the center than at the edges.

Jan. 7, 1871.—A very marked phenomenon is represented in figs. 5 and 6. A white oval spot was seen preceded by two brownish spots at $6^h\ 57^m$. It was afterwards seen only by glimpses,

until $7^h\ 36^m$ when it reappeared, but with a change of relative position; it was then between the brown spots. The shadow of the second satellite, very black at first, dimmed as it came to the center, and became elongated.

Jan. 13, 1871.—Two white spots seen near the northern edge seemed to change in relative position in the course of half an hour.

Jan. 16, 1871.—The passages of the first satellite and of the shadow were carefully watched. The satellite was seen through nearly the whole transit; it was lost for about 20 minutes when near the center—at this time the shadow became elongated. When the shadow entered upon Jupiter, it seemed to have a penumbra around it, and to be preceded by a small white spot. A large white spot was seen above the most northern dark belt.

Jan. 19, 1871.—Three large white spots were seen on the dark equatorial belt. The third satellite was on the planet and was smaller than any one of these spots.

In watching the changes of Jupiter's bright cloudy belts or of its dark bands, one is continually reminded of the changes in the sun's photosphere. Although the variations are less marked on Jupiter than on the sun, yet it is true of both, that drawings made at intervals of half an hour would show different relations of dark and light spots.

The changes in the satellites seem to me peculiar. I have watched the first satellite a good deal, and while I have never seen it enter upon, or leave the disc as other than a white circular object, either I have lost it at the center, or it has changed in shape and color,—becoming elongated toward the polar regions, and assuming a reddish-brown hue. The impression made upon the observer is that of the interposition of some medium through which it is seen dim and distorted.

ART. LVII.—*On the Physical Constitution of the Sun;* by Professor W. A. NORTON.

AMONG the recent theories of the Physical Constitution of the Sun, based on the later discoveries, astronomical and spectroscopic, that propounded a few years since by M. Faye* has been most favorably received. It is an essential feature of this theory that the sun's mass consists wholly, or in a great degree of gases or vapors; and that a process of interchange of solar matter between the interior and the photosphere is in incessant operation, in ascending and descending currents, by which the

* Comptes Rendus, vol. lx, pp. 89 and 138.

solar radiation is maintained. In a paper by J. Homer Lane, on the Theoretical Temperature of the Sun, &c., published in this Journal, July, 1869, it is elaborately argued, and appears to be successfully maintained, that the great rapidity of circulation required by this theory cannot subsist consistently with the received laws of gaseous circulation. Quite recently another theory of the sun's physical constitution has been propounded by Professor F. Zöllner of Leipzig; based mainly on the well established fact that the solar protuberances, conspicuously visible in total eclipses, and observable at all times with the aid of a spectroscope, are most of them due to violent eruptions of masses of incandescent hydrogen.* He remarks that "it is impossible, without passing beyond the well known analogies necessary for the explanation of cosmical phenomena, to assign any other cause to these eruptions than the difference of pressure of the gases emanating from the interior and from the surface of the sun. To make such a difference of pressure possible it is necessary to admit the existence of a separating stratum between the inner and outer strata of hydrogen—the latter of which, as is well known, forms an important portion of the solar atmosphere. In reference to the physical constitution of this stratum, we must furthermore assume that it cannot be gaseous, and must therefore be either solid or liquid." He remarks further, that "with regard to the inner masses of hydrogen bounded by that stratum, two suppositions are possible, viz: 1. The whole interior of the sun is filled with incandescent hydrogen gas, which would make the sun an immense bubble of hydrogen surrounded by a liquid glowing envelope. 2. The masses of hydrogen, bursting out into protuberances, are local collections in bubble-like caverns, which form in the superficial layers of a liquid glowing mass, and burst through when the pressure of the confined gas increases." Prof. Zöllner adopts the latter supposition as the more probable of the two.

This theory may furnish an adequate supposable cause for the observed eruption of incandescent masses of hydrogen, but its fundamental hypotheses have no secure ground to rest upon. The notion, that the sun's photosphere is in the liquid state, is irreconcilable with the astonishing rapidity with which changes often occur on the sun's surface, and also with the fact that the vast elevated masses, seen as the faculæ, occasionally retain the same position for several days; and though suggested long since, has not, to my knowledge, been adopted by any astronomical observer. No hypothesis of the possible origin of the sun's spots, upon this idea, has been framed that affords a satisfactory explanation of even their more conspicuous features and phe-

*Journal of the Franklin Institute, Nov., 1870; also Philosophical Magazine, Nov., 1870.

nomena. To this remark the theory advanced by Prof. Zöllner, viz: that "the nucleus of the solar spots is a scoriaceous product of local cooling on a liquid surface, and the penumbræ clouds of condensation, which surround at a certain height the coasts of these islands of slag, offers no exception." It is not new, and has been already overthrown by the investigations of M. Faye.* The other fundamental hypothesis of Professor Zöllner's theory of the physical constitution of the sun, viz: that the masses, which burst out into protuberances, are local collections in bubble-like caverns, which form in the superficial layers of a liquid glowing mass, does not derive any support from analogical facts. It must be regarded as a pure hypothesis, unsustained by any inherent probability, or by any known fact, other than that which it is framed to explain. Besides, an hypothesis which brings the hydrogen in eruptive, or streaming masses, to the sun's surface, does not suffice. Another arbitrary hypothesis is required to dispose of the hydrogen which has thus been accumulating above the sun's photosphere for an indefinite period of time.

Such being the state of the case with regard to the recent attempts to discover the secret of the sun's physical constitution, in the light of the late remarkable discoveries, we seem to be in this dilemma; whatever conception is formed of the condition of the sun's photosphere—whether liquid or gaseous—it appears to be contradicted by received principles, or controverted by established facts. We are thus naturally led to suspect that either some physical cause has been hitherto left out of account, which plays an important part in solar phenomena, or else the conception adopted of the mechanical condition of the solar vapors is radically at fault. It appears to me that good and sufficient reasons may be urged that will justify both these grounds of suspicion; and that a new point of view may be gained from which we may obtain a deeper insight into the physical processes in operation on the sun.

It is a little remarkable that it should have been hitherto assumed that the facts and laws of Terrestrial Physics can alone furnish a true philosophical ground for a theory of Solar Physics; and that no serious attempt should have been made to obtain additional light from known processes in operation on a cosmical scale in the regions of space. There is a class of bodies, some of which in their periodical excursions through the fields of space approach quite near the sun, and which are in general conspicuously subject to influences of a powerful nature exerted by the sun, besides the force of gravitation. It cer-

* Comptes Rendus, vol. lxi, p. 1089.

tainly seems natural to expect that these cosmical bodies might give us some insight into the nature of the forces in operation at the sun's surface. It is assuredly too late to urge that the transformations which they undergo under the sun's influence are wholly involved in mystery; for it has certainly been satisfactorily established that a portion of the cometary matter becomes subject to a *solar repulsion*, and is urged away by this force with a high velocity, and to great distances from the sun, and that this repulsion augments in intensity as the comet approaches the sun.* Now if such an energetic force of repulsion emanates from the sun, and operates on cometic matter at all distances, both small and great, according to the law of inyerse squares, there is assuredly a high probability that it may play an important part on that vast arena, where solar forces are obviously engaged in fierce contention. It may be conjectured that the solar vapors are entirely different substances from, and wholly unlike, in their physical state, the cometary vapors that appear to be so exceedingly subtil. But it is certainly more philosophical to suppose that the same substances, or substances possessed of the same general properties, are present in all cosmical bodies, and the earth. Besides we are not without direct evidence on this point. Huggins, by examining the spectrum furnished by the light emitted from the Comet II, 1868, detected the presence of the vapor of carbon in the brighter portions of the comet. "He has been able to discriminate between the light of the nucleus of a comet and that of its tail. The nucleus is self-luminous, and its substance is in the form of ignited gas. The coma shines by reflected light as clouds do."

If, as is now conceded by astronomers, the tail of a comet is made up of matter detached from the general mass of the comet, by reason of a repulsive action exerted by the sun, it must also be admitted that the matter expelled is not all urged away by the same intensity of force, and with the same velocity; for we find that it is much more widely dispersed in the plane of the cometary orbit than is consistent with this supposition. For example, I have shown, in my theoretical discussion of Donati's Comet,† that if we conceive particles of matter to have been expelled from this comet, with a certain small lateral velocity, and urged away during a certain interval of time by a solar repulsion bearing to the force of gravitation the ratio of

* This is generally, if not universally, admitted by astronomers. The author has undertaken in former numbers of this Journal, to establish by rigorous calculation that the luminous train of Donati's comet was developed by a force of solar repulsion coöperating with the attraction of gravitation—both varying according to the law of the inverse squares. (See this Journal, vol. xxxii.)

† This Journal, II, vol. xxxii, pp. 54–66.

1·213 to 1, they would, at the end of the interval, have been found distributed over a narrow band coincident, at its forward line, with the curved preceding side of the tail of the comet; and that the other portions of the tail must have been composed of matter subject to various degrees of solar repulsion less than this. In fact the definite conclusion was in this way reached that the preceding half of the tail consisted of matter repelled from the sun with a force varying between the limits 1·213 and 0, and that the following half was for the most part composed of matter detached from the comet simply by reason of a weakened gravitation toward the sun,—the intensity of the force of gravitation along the following side of the tail being 0·455. There would seem then to be no alternative but to admit that the tail of Donati's comet was composed of different substances, (or else of one substance in different physical states) subject to a repulsive action from the sun of various degrees of intensity; and either prevailing over the sun's attraction of gravitation, or partially counteracting it, and so giving rise to an effective repulsion for certain of these substances, and to a diminished gravitation for others. The simplest theoretical explanation that can be given of this state of things is to suppose that the *solar repulsion consists of a series of impulses propagated in waves through the ether of space, and taking effect upon atoms of different sizes with varying intensity.* It is obvious that if this be true, the smaller the atom the more effective should be the repulsion as compared with the gravitating force soliciting the atom; since the ratio of the two forces should be proportional to the surface divided by the volume of the atom,—assuming that the mass is proportional to the volume, or that all atoms have the same density. We are thus incidentally led to infer that the larger comets consist of a variety of substances, like the earth.

The question now arises what can be the origin of the force of solar repulsion. There is another side of the diversified picture presented by cometary transformations under the sun's influence, which gives some intimations on this point. Not only is a certain portion of the cometary matter repelled by the sun, but it is also repelled by the nucleus of the comet. We see in large comets, a series of envelopes rise at intervals from the nucleus, on the side turned toward the sun, and recede at a nearly uniform rate until they become dissipated by the sun's repulsion. Luminous jets also stream out at times from the same side of the nucleus. These phenomena, it can hardly be doubted, are in some way the effect of the sun's heat. The simplest and most probable conclusion is that the ejecting force which is brought into play by the sun's heat is the direct repulsive energy of the heat received by the comet. We are thus

led to infer that *the repulsive action exerted by the sun upon matter in the state of the cometary vapors, probably consists, either wholly or partially, in repulsive impulses propagated in the heat waves proceeding from the sun.*

Let us now see whether any confirmation of these inferences, and any additional light in the direction of our present inquiry, can be obtained on the substantial ground of Terrestrial Physics. The definite question presented for consideration, is whether the results of observation or experiment afford any indication of a direct repulsive action exerted by radiant heat on the atoms of bodies. It is universally admitted that radiant heat, when imbibed by a body, acts as a repulsive or separating agency among its molecules. It is also conceived that the conduction of heat is by radiation from atom to atom. The most natural inference from these facts is that the waves of radiant heat, which pass from atom to atom, directly urge the atoms away from each other by repulsive impulses. Instead, however, of adopting this simple idea, physicists have generally been inclined to refer the expansion of bodies from heat to some mode of motion of the atoms, originated by the heat received; though no detailed satisfactory explanation has yet been given of the manner in which such motions would directly originate an expansion. Strangely enough this notion is even entertained by physicists who regard heat as the only cause of the repulsion subsisting among the molecules of bodies. It should here be noted, that if the expansion of all bodies of matter from heat is to be ascribed to a direct impulsive, or repulsive action of heat waves proceeding from one atom and falling upon the surrounding atoms, then this force takes effect at the greatest distances by which the atoms are separated in the rarest gas under the feeblest pressure; and we would thus be led to expect that heated bodies in contact with each other might manifest signs of repulsion.

In point of fact, many evidences of a heat repulsion subsisting between particles of different bodies, in contact or in close proximity, have been adduced by different experimentalists, and writers on physics, some of which may be briefly mentioned.

1. "When pure silica, in an extreme state of division is highly heated, the slightest motion then causes the particles of the powder to slide over each other, and the surface of the powder is thrown into undulations almost like those of a liquid."

2. A rise of temperature is attended with a decrease of capillary attraction. Also the frictional resistance to the flow of water in pipes is diminished by heat.

3. "The spheroidal state of liquids is a complicated result of four distinct causes. The most influential is the repulsive force which heat exerts between objects which are closely approximated to each other."*

4. The vibrations of heated metals, as shown in "Trevilyan's Instrument," or "rocker," resting on a block of metal, are probably due to the direct repulsive force of heat, as maintained by Professor Forbes, of Edinburgh, in opposition to Faraday, who conceived that they were attributable to the sudden expansion by heat of the body on which the rocker rests. Faraday's explanation of these curious phenomena is adopted by Tyndall, who endeavors to overthrow Prof. Forbes's theory. His experiments serve to disclose the fallacy of certain features of the theory, but do not dislodge the fundamental idea that the phenomena are due to a force of heat-repulsion. This might be made apparent if we had space for a statement of the general principles on which the explanation rests, and for a detailed discussion of the results of the experiments.

Let us now consider if any sufficient evidence exists of a general force of molecular repulsion in operation at all temperatures,—beyond the sphere of sensible adhesion, or cohesion. We need, in fact, to look no farther for this than to the simple fact that in the ordinary contact of bodies the interval of distance between them, minute as it is, much exceeds the range of the attraction of cohesion, or adhesion; for in such contact the weight of the upper body is counteracted by a repulsion between the molecules about the point of contact. Dr. Robison has shown in his System of Mechanical Philosophy, that if two glasses, one slightly convex, the other flat, are placed on each other and pressed by a force of 1000 pounds to the square inch, they are still at the distance from each other of the thickness of the top of a soap bubble just before it bursts, or at least $\frac{1}{4}\frac{1}{3}\frac{1}{6}$th of an inch. In effecting this contact there was no evidence of any attraction existing at distances greater than that at which the contact occurred. A similar remark may be made with regard to all cases of the apparent contact of homogeneous substances under a moderate pressure. It is only by increasing the pressure more or less, that the contiguous particles can be brought within the range of their reciprocal attraction of cohesion. When the particles are readily displaced among themselves under the direct action of a pressure, or blow, as in the case of soft or malleable substances, a permanent union may be effected without difficulty between the surfaces; that is, the outer repulsion of some of the particles may be overcome, their attraction of cohesion brought into play at the reduced distance, and an equilibrium established at the neutral

* Miller's Physics, p. 285.

point between this attraction and the inner repulsion. This occurs in the welding of iron.

Other evidences of an effective repulsion in operation between the molecules of bodies in contact, or in close proximity, are cited in treatises on Physics; although it is not always distinctly recognized that the sphere of its action lies entirely without that of the effective molecular attraction. Now what is the range of this *effective* repulsion between bodies. It obviously extends only to a small distance. Cavendish's well-known experiment has established that, when bodies are separated by considerable distances they tend toward each other by the attraction of gravitation. But are we therefore to conclude that the repulsive action, so energetic at the near approach of the molecules, has vanished altogether when they are a considerable distance apart. Is it not more probable that this force is confined to the surface molecules, and disappears at moderate distances, in comparison with the attraction of gravitation which is the result of the action of the entire masses on each other, because it decreases according to the inverse squares of the distance between the surfaces instead of the distance between the centers. I have elsewhere shown* that the force of gravitation cannot be the attraction of cohesion operating at considerable or great distances. It is a force *sui generis*, entirely distinct from the forces of molecular attraction and repulsion in operation at minute distances, and determining the constitution of bodies and their mechanical properties; and operates in conjunction with, but independently of, these molecular forces.†

In view of the concurrent testimony that we have now seen is afforded by the two departments of Cometary, and Terrestrial Physics, it will be admitted that, in attempting to gain a new insight into the physical constitution of the sun, and the pro-

* Philosophical Magazine, vol. xxxviii. p. 38.

† It ought here to be stated, that in my paper on Molecular Physics published in this Journal, vols. xxxviii, xxxix and xl. I have deduced from the fundamental conception of a primitive molecule (or chemical atom) adopted, a force of molecular repulsion operating beyond the sphere of the molecular, or cohesive attraction; and reached the conclusion that this force has its immediate origin in the physical change to which the development of heat is in every instance due, viz: an inward or contractile vibratory movement of the electric envelopes by which all atoms are conceived to be surrounded, as well as by ethereal atmospheres. It is accordingly termed the molecular heat-repulsion. The repulsive energy of heat in operation on any molecule, is the sum of all the ethereal impulses developed by such movements of the envelopes of other molecules, (whether originating in the attraction exerted by the central atoms on their envelopes, or in an external collision or pressure), and propagated to the molecule. From the principle of interception of wave-force it results that the external repulsive action exerted by a solid body is confined to the surface molecules; while a force of heat-repulsion is propagated to an indefinite distance from all the molecules of a gas.

cesses of change in operation on its surface, we are at least entitled to assume the following as probable hypotheses.

1. That the sun exercises a repulsive action upon the molecules of every gas or vapor that subsists at its surface, or is at any time in any part of the region of space exterior to the surface; that this force is the sum of all the heat impulses propagated in ethereal waves from all the gaseous molecules posited above the solid or liquid body of the sun, and from the surface molecules of this central mass, except in so far as these impulses may be intercepted in their passage; and that it is opposed to the force of gravitation, which is due to a virtual attraction of the sun's entire mass,—so that the effective force soliciting any gaseous molecule is the difference between these two forces, attractive and repulsive, by which it is urged.

2. That the force of solar repulsion, since it consists of impulses propagated in ethereal waves, is comparatively more effective in proportion as the atomic weight of the solar vapor is less; it being assumed that the quantity of matter in any atom is proportional to its volume.

3. That in a hypothetical condition of equilibrium of the sun's atmosphere the elastic force of each of its vaporous constituents, at any depth, will consist in the intensity of the effective heat impulses tending to urge its molecules outward; which will be counteracted by the weight of the superincumbent portion of the atmosphere. Now, let us assume, for the moment, that at some anterior epoch in the sun's history, all the present vaporous constituents of the sun's atmosphere were diffused throughout a space exterior to the central body of the sun and limited by the spherical surface (A), at which the molecules of the vapor of greatest atomic weight are in equilibrium, under the action of their own weight and of the heat-repulsion urging them upward. This hypothetical state of things could not continue, since the atoms of each of the other solar vapors would be urged upward by an effective force. If we conceive a small quantity of each of them to escape from all points of this surface, the rising vapors will ascend to greater heights in proportion as their atomic weights are less, and finally, when the equilibrium is attained, form a series of spherical envelopes, wholly detached from each other, and arranged in the order of atomic weights;—beginning with the heavier metallic vapors, and terminating with the lighter (potassium, sodium, &c.), and the permanent gases, with hydrogen outermost. If other small portions of each of the vapors were to rise from the surface, A, they would serve to augment the thickness of the envelopes already formed; and the same would be true for each successive discharge. The final result would be the same if the discharge were continuous during a certain interval of time, as

would naturally happen. After a certain amount of the solar vapors have escaped, contiguous envelopes might interpenetrate each other more or less. What it is especially important to observe, is, that *throughout the whole depth intercepted between each envelope, and the outer limiting surface,* A, *of the vapor of greatest atomic weight, every atom of the substance of which the envelope is composed, that may chance to be present, is urged upward by a force of repulsion.* If, as we must suppose, the rise of the solar vapors from the surface, A, continues for an indefinite time, the interpenetration of contiguous envelopes would increase, and eventually a condition of equilibrium would be attained; if the sun's temperature remained the same. But if this temperature were to increase, as it must down to a certain epoch in the process of consolidation, the process above indicated would be continually renewed. It is still more important to observe, that if there were any cause in operation withdrawing continually at short intervals a portion of one or more of these rising vapors, a statical equilibrium would not be reached; and it would be permanently true that *for every such vapor there would be a region of repulsion,* as above stated, *extending from its envelope down to the outer limit,* A, *of the vapor of greatest atomic weight.* Throughout this region the vapor would be perpetually rising, taking the place of that which is withdrawn, and so maintaining a *dynamical equilibrium.* The depth of this region would be the greatest for hydrogen, the outermost gas (unless there is some solar vapor of less atomic weight than hydrogen). Now it is easy to see that a certain physical cause tending to produce such results, must come into operation at some stage of the sun's process of consolidation. As conceived by Faye, the cooling going on at the outer surface must eventually bring the temperature there down to the point at which the vapors having the highest affinity for oxygen will undergo combustion. The products of such combustion, being compound molecules, will have a greater weight in comparison with the repulsion to which they are exposed, than the simple molecules before the combination took place, and hence they will descend, more or less rapidly, into the depths of the photosphere. To all appearance the sun is now passing through this period of its physical history, as supposed by Faye; and in the "granulations" which give to the solar disc a mottled appearance (Herschel's "subsiding chemical precipitates,") we probably discern the products of the combustion occurring in the upper photosphere and determining its outer limit, in the act of descending. The continual upward flow from the depths of the photosphere, of the hydrogen, oxygen, and the lighter metallic vapors, will bring about the necessary intermixture of oxygen with the other vapors. This must occur below the natural

outer limit of the hydrogen envelope; and we know that as a matter of fact, the chromosphere, composed chiefly of hydrogen, extends above the photosphere.

If the products of the surface combustion were all to descend indefinitely into the vaporous photosphere, without undergoing decomposition, no farther visible effects would ensue. We could only follow with the mind's eye the gradual growth of the central nucleus of the sun, and recognize that we probably have before us a picture of the process by which the materials of the earth's crust were fashioned and accumulated in the earlier ages of its history. But the probability is that the descending masses would eventually arrive at a depth where the higher temperature would effect a dissociation of the combined elements (as Faye supposes). This must inevitably happen unless the tendency of the heat, that augments with the depth, is counteracted by the opposing tendency of the increasing gaseous pressure. By reason of these opposing tendencies it may well happen that there may be a certain region of dissociation of limited depth, above and below which decomposition would not occur. But it is to be observed that it does not follow that all of the products of surface combustion as they pass through such a region would be decomposed; since the reduction of temperature attending every instance of decomposition tends to prevent decomposition of other surrounding masses in the act of descending.

This sudden dissociation of large masses of combined elements, though occurring at certain depths within the photosphere, it will be seen may eventually play a conspicuous part at the surface. Unless the region of dissociation should lie below that of repulsion for the elements separated, these elements after separation will be urged upward by the effective force of repulsion, ascend rapidly, and emerge with a high velocity above their respective envelopes. The ascensional velocities attained will be greater if large masses are suddenly decomposed. The masses of hydrogen set free should attain to the greatest velocity, and rise to the greatest height. They should rise, in eruptive masses, above the hydrogen envelope, or in other words, the chromosphere. According to Lockyer, in the solar protuberances, the ascending hydrogen has in some cases, a velocity as high as 120 miles per second, and rises to a height of more than 40,000 miles.

A vertical jet of hydrogen, having a projectile velocity of 120 miles per second, should attain an altitude of 43,000 miles, if the solar gravity were constant for that altitude. Some prominences have extended to a height of 100,000 miles above the sun's photosphere. Prof. Respighi, has even noticed instances of an elevation of 160,000 miles. Such enormous

heights imply either a greater initial velocity than 120 miles per second, or that the full energy of the solar attraction does not take effect on the eruptive masses of hydrogen, in the region above the photosphere. From our theoretical point of view, we perceive that the latter supposition should be true; since the solar repulsion should be in operation above the hydrogen envelope, or the chromosphere, diminishing the gravitating tendency.

The metallic vapors set free in the region of dissociation, should rise to heights varying with their atomic weights. Some of them, especially the lighter ones (sodium, magnesium, calcium, &c.), may acquire velocities sufficient to bring them above the chromosphere. In fact the spectroscope has detected besides hydrogen, magnesium, sodium, iron, and chromium, in the solar protuberances. Lockyer states that he has invariably found that in solar storms, the chromospheric layers are thrown up in the order of vapor density. He regards the chromosphere as built up of the following layers, which are in the order of vapor density in the case of known elements: a new element giving the green coronal line in the spectroscope, hydrogen, another new element, magnesium, sodium, barium, iron. He remarks that "all the heavier vapors are at or below the level of the photosphere itself."*

The green coronal line was traced in the late eclipse by Profs. Young and Winlock as far as 16′ or 425,000 miles from the sun's limb. From our present theoretical stand-point, we naturally infer, as Lockyer has already done from his observations, that the element present in the solar corona which gives this line is much lighter than hydrogen. We see also that an element several times lighter than hydrogen might be subject to a solar repulsion that would predominate over the attraction of gravitation at all distances, and urge the subtil vapor indefinitely away from the sun. Since the same line is seen in the light of terrestrial auroras, we must conclude that the same substance is present in our upper atmosphere;—either in a permanent upper layer, or derived from the sun (as I have elsewhere maintained). We must infer also that it is magnetic, which apparently cannot be the case unless it takes on the condition of compound molecules. Such compound molecules might become dispersed in the upper atmosphere of the earth, or in the photosphere of the sun, by electric discharges or sudden evolutions of heat; and then the separate atoms repelled off, forming the streamers of the corona and aurora, illuminated either by electric

* It is admitted by Angström, and Zöllner, that the absence of spectroscopic indications of oxygen and nitrogen in the sun, is no sufficient evidence that these gases are really wanting in the sun's atmosphere.

light, or in the case of the corona in part also by reflected solar light.*

The probable origin of the sun's spots, and other questions of solar physics that claim attention, must be left for future consideration. I will only remark here, that it has long been apparent that the diverse phenomena which occur at the sun's surface are traceable, more or less directly, to the action of some form of eruptive force. *The present investigation seems to have led to the discovery of the true nature and origin of this force; and at the same time to have revealed the process by which the sun's radiation is maintained.* The primary source of the solar heat being, doubtless, as now generally believed, the process of condensation maintained by the force of gravitation.

It is worthy of remark, in conclusion, that as comets directed our attention, at the outset, toward the sun, so the sun, in its turn, leads us back again to our starting point; since we see that if we transfer to cometary bodies the physical structure we have recognized in the sun's upper photosphere, viz: the existence of a succession of light vaporous envelopes, subject to the energetic action of the force of heat repulsion, the mystery in which some of the curious transformations they undergo, have hitherto been involved, seems to be in a great degree dispelled. No one doubts that comets are chiefly composed of very light vapors; though some of the larger ones may have a solid nucleus. If, as intimated, certain observed cometary phenomena indicate that these vapors, like the solar vapors, are arranged, for a certain depth at least, in envelopes, which are liable to be greatly expanded, or even wholly expelled by the increasing amount of heat received from the sun, we have in the probable physical structure of comets, another indication that these bodies were originally detached from the sun's photosphere, in addition to that furnished by certain features of the cometary motions.†

* It is also conceivable that the subtil vapor streaming off in the coronal rays, has been set free by dissociation like the hydrogen, from some other element of a compound substance, in the depths of the photosphere. However this may be, it can hardly be doubted that the ascent and descent of the solar vapors, and the combinations and decompositions going on among them, must be attended with disturbances of electric equilibrium, from which decided effects must result.

† Norton's Astronomy, revised edition, p. 276.

ART. LVIII.—*On the Composition of Permanent Illuminating Gas obtained from the decomposition of Petroleum Naphtha;* by H. H. EDGERTON. With a prefatory note by B. SILLIMAN.

THE conversion of the light napthas resulting from the rectification of Pennsylvania petroleum into a permanent gas, suited for economical use as an illuminant, either by itself or when mixed with poor gas, or atmospheric air as a diluent, is a problem of no little importance; especially in view of the enormous volume of these light products, equal to at least one-eighth part of the total production of crude petroleum. A process for converting this volatile material into a permanent gas has been devised, and is coming into notice under the name of "Rand's process," which is in fact founded upon an invention patented some years since by Dr. L. D. Gale. In this process the vapor of naphtha evolved in a distillating apparatus by a steam coil is carried into an iron retort heated to redness where it is in great part converted into permanent gases of very high illuminating power. Small portions of the denser oils which escape destructive distillation are delivered by a syphon into a suitable receptacle; while the gas, after cooling is carried to the holder and is fit for immediate use. It is so rich, however, in illuminants as to be unfit for use in common gas burners, and hence is usually reduced by admixture with atmospheric air, of which it requires about an equal volume to bring it to a standard of 25 candles by the photometer.

As this problem possesses considerable scientific interest, aside from its economical importance, I have requested Mr. H. H. Edgerton, Superintendent of the Gas works at Fort Wayne, Indiana, who is a well instructed and skillful gas chemist, to communicate for publication his analytical results upon the constitution of the naphtha gas, which are subjoined.

The "Memphis Gas" quoted in these analyses is the gas made at Memphis, Tennessee, by this method, that city being thus lighted. By "Fort Wayne N. Gas" Mr. Edgerton means the naphtha gas made by himself at Fort Wayne. In a letter Mr. Edgerton says he has calculated the gases which are not absorbed by Nordhausen acid as methyl or marsh gas, and the absorbable gases as $C_4H_4 + C_8H_8$, although he adds, "I am convinced these gases do not co-exist, but go to form an intermediate gas, of less simple relation of volumes."

The economical details of this interesting research are given in a separate form elsewhere. It will be a source of great satisfaction should this method of utilizing light naphtha become an established industry, since in this manner alone can we hope, by consuming the raw material, to avoid those constantly recur-

ing disasters from the use of "dangerous kerosene," made dangerous by the fraudulent addition of these volatile hydrocarbons, by reason of which many hundreds of lives are annually sacrificed. B. S.

Constituents of Naphtha Gas reduced to 100 *volumes.*

"Memphis Gas."

Hydrocarbon illuminating gases,	25·42
Marsh gas,	34·16
Methyl,	3·29
Nitrogen,	32·24
Oxygen,	4·89
	100·00

"Fort Wayne Gas."

		1st analysis.		2d analysis.	
Elayl (Olefiant gas),	C_4H_4,	37·54	55·81	38·28	55·81
Ditetryl (Butylene),	C_8H_8,	18·27		17·53	
Marsh gas,	C_2H_4	13·98	44·19	13·98	44·19
Methyl,	$(\overset{2\text{ vol.}}{C_2H_3}\ \overset{4\text{ vol.}}{C_4H_6})$	30·21		30·21	
		100·00		100·00	

Condensation of Hydrocarbons absorbable by concentrated Sulphuric acid. In analysis of Memphis gas.

Gas employed,	41·47	of which	7·143	absorbable by SO_3
Less Nitrogen,	13·37		20·957	non-absorbable.
Combustible gas,	28·10			

According to previous analysis, due non-absorbable gases.

	Due non-absorb.	Vol. absorb.	Due absorb.	Per vol.
Carbonic acid,	22·80	7·143	19·40	2.716
Oxygen used,	52·136		21·50	3·010
Contraction,	50·293		7·21	1·009

Fort Wayne Naphtha Gas.

Gas employed, 6·819, of which 55·81 pr. ct. absorb. Vol. 3·806.

	Due non-absorb.	Per vol.	Due absorb.	Per vol.	Total.
Carbonic acid,	5·073	1·683	10·103	2·654	15·176
Oxygen used,	9·081	3·013	15·604	4·100	24·685
Contraction,	7·023	2·339	9·129	2·398	16·152

Second trial.—Gas employed, 7·000, of which

	Non-absorbable. 3·093	per vol.	Absorbable. 3·907	per vol.	Total.
Carbonic acid,	5·208	1·683	10·260	2·626	15·468
Oxygen used,	9·321	3·013	16·204	4·147	25·525
Contraction,	7·210	2·339	9·381	2·401	16·591

Analyses of Petroleum Naphtha Gas, February and March, 1871.

	V.	V. KO	V. Pyro gal.	V. SO_3HO	CO_2 Pr. ct.	O Pr. ct.	Hydro-carb. Pr. ct.	R. V.	R. V. +air.	O added.	N added.
Memphis Gas,* -----	167·18	167·18	160·66	118·13	None.	4·91	25·42	21·13	217·03	280·67	162·90
" " † -----										2·08	
Ft. Wayne N. Gas,‡	41 47	----	----	----	----	----	----	----	541·40	104·78	395·15
" " "	193·15	193·15	192·36	107·81	None.	0·41	55·81	13·49	210·51	41·29	155·71
" " "	----	----	----	----	----	----	----	19·46	351·16	69·52	262·17
" " "	----	Bunse n's met hod.	----	----	----	----	----	19·59	252·93	269.90	184·43
										48·91	
" " " ¶	7·36	----	----	----	----	----	----	----	144·76	16·96	
										28·80	108·61
	7·21	----	----	----	----	----	----	----	184·02	37·06	139·75
									119·29		
" " **	----	----	----	----	----	----	----	6·56	119·07	23·58	88·93

TABLE OF ANALYSES—continued.

	After explo-sion.	R. V. KO.	R. V. Pyro-gal.	R. V. +H	R. V. 2d explosion.	R. V.—RN	CO_2 found.	O used.	C con-tracted.	For 1 or 100 volumes. CO_2	O	C
Memphis Gas,* ---	249·28	235·05	----	608·88	392·41	13·08	14·23	32·54	31·39	----	----	----
" " † ---	483·90	441·70	408·51	----	----	28·10	42·20	73·63	57·50	----	----	----
Ft. Wayne N. Gas,‡	180·34	158·56	156·26	----	----	12·94	21·79	39·00	30·16	1·68	3·01	2·33
" " "	308·41	277·31	263·76	----	----	17·88	31·10	55·97	42·75	1·74	3·13	2·39
" " "	230·76	205·76	----	347·41	293·89	16·21	25·00	48·03	39·14	1·63	3·18	2·55
" " " ¶	128·17	112·70	108·95	----	----	7·00	15·47	25·04	16·69	2·21	3·29	2·37
		152·20										
	167·87	152·70	----	188·57	151·16	6·819	15·18	24·68	16·15	----	----	----
" " " **	106·11	97·09	----	133·82	112·78	5·461	9·018	16·522	13·186	1·651	3·025	2·414

V.=Volume. R. V.=Residual Volume. R. V.—RN=Residual vol. employed after deducting N found.

* Memphis gas before going into "air mixer," supposed to be pure Naphtha gas.

† To find condensation of absorbable hydrocarbons.

‡ Yielded from commercial benzine at rate of 80 cubic feet per gallon.

§ Analysis of residual gas from same after standing over water.

‖ Another trial of residual gas after absorption of illuminating gases, the absorption made on a quantity contained in a glass holder; sp. gr. of same by Bunsen's diffusion method ·779.

¶ Combustion of same gas (No. 5, second series) before absorbing hydrocarbons to ascertain condensation—two trials.

** Analysis of residual gas after passing No. 5 through Liebig bulbs containing bromine, through water and caustic potash solution. Weight taken before and after of each:

	Before.	After.		
Bromine, ----	52·402	67·760	Weight of hydrocarbons absorbed,	4·788 grams.
Water, --- -	95·580	106,220	Vol. of gas passed, ----------	Lost.
Potash, -----	74·770	53·550	" " residual gas, ----------	201·06 cub. in.
	222·752	227·530		
		222·752		
		4·778	Sp. gr., ---------- ----	·796

These analyses agree in the main, that one volume of absorbable gas forms on explosion $2\frac{2}{3}$ vol. of carbonic acid, and the illuminating power, compared with olefiant gas, is one-third greater, or as 1 to $1\frac{1}{3}$, according to Mr. Lewis Thompson's rule. The sp. gr. of hydrocarbons, found by an indirect method, was 1·271. The candle-power of the Fort Wayne gas would be, therefore, according to the chemical standard 74·41 candles, or 5 to 6 times that of ordinary coal gas. The actual candle-power by photometric test is much higher.

The analyses were all made (with one exception) with Prof. Frankland's apparatus. Owing to a disproportion of parts, the "laboratory tube" being exceedingly small, holding only one-third contents of measurer, but a very small quantity of gas could be analyzed,—about $\frac{1}{2}$ c. c. when nitrogen was present. To give an idea of the experimental error on so small a quantity, four analyses of *air*, by electrolytic H are added.

1st.		2d.	
Air emp. (expanded vol.)	62·5	Air emp. (unex. vol.)	6·877
After H,	125·9	After H,	14·519
After explosion,	87·3	After explosion,	10·182
$\frac{1}{3}$C=12·87 per ct.	O=20·59	$\frac{1}{3}$C=1·4457 per ct.	O=21·023

3d.		4th.	
Air employed,	14·827	7·547	
After H,	30·088	14·790	
After explosion,	21·028	10·496	
$\frac{1}{3}$C=3·020 per ct.	O=20·368	$\frac{1}{3}$C=1·431 per ct.	O=18·969

Fort Wayne, Indiana, March 20, 1871.

Art. LIX.—*A Historical Note on the Method of Least Squares;* by Cleveland Abbe, A.M.

It is well known that the "Method of Least Squares," although first published in printed form by LeGendre in 1806, in his "Nouvelles Methodes," was first invented by Gauss as early as 1795, and had for years been taught by him in his lectures to his students at Göttingen. It was, however, some years before the Gaussian method came into general use, and especially were English scholars very slow to acquaint themselves with its merits. I have, therefore, been much interested in finding that, in 1808, Professor Robert Adrain, at that time in New Brunswick, N. J., published the method of least squares in the "Analyst," having been independently led to this invention by the study of a prize problem offered some months previously in that periodical.

As the editor of, and chief contributor to, the Mathematical Correspondent, the Analyst, and the Mathematical Diary, and

as Professor in Columbia College and in Pennsylvania University, as well as by his correspondence, Dr. Adrain is well known to have contributed powerfully to the progress of Mathematical studies in this his adopted country—(he was born and educated in Dublin)—and his apparently independent demonstration of the method of least squares seems quite in accordance with the originality shown in many other of the elegant solutions offered by him to the different problems on which he busied himself. A number of interesting and probably valuable mathematical manuscripts still remain in the possession of his family at New Brunswick, New Jersey, which it is to be hoped may some day see the light. At present I would offer toward the history of mathematics in America the following extracts from the Analyst and other publications.

The problem "to correct the distances and bearings of a survey, so as to deduce the most probable area of the enclosed field," had been proposed by Professor Patterson in a previous number of the Analyst, and after being a second time renewed as a prize question, was at length in number IV, solved by a course of special reasoning, by Dr. Bowditch, to whom Dr. Adrain awarded the prize. Dr. Bowditch's results coincided with what would have been deduced had the Gaussian method been applied to this case. Immediately following Dr. Bowditch's special solution, the editor adds his own solution of the more general problem as follows: (The Analyst, pp. 93–95 inclusive).

"*Research concerning the probabilities of the errors which happen in making observations.*"

"The question which I propose to resolve is this: supposing AB to be the true value of any quantity of which the measure by observation or experiment is Ab, the error being Bb; what is the expression of the probability that the error Bb happens in measuring AB?

Let AB, BC, &c., be several successive distances of which the values by measure are Ab, bc, &c., the whole error being Cc; now supposing the measures Ab, bc, to be given and also the whole error Cc, we assume as a self-evident principle, that the most probable distances AB, BC are proportional to the measures Ab, bc; and therefore the errors belonging to AB, BC are proportional to their lengths, or to their measured values Ab, bc. If therefore we represent the values of AB, BC or of their measures Ab, bc by a, b, the whole error Cc by C, and the errors of the measures Ab, bc by x, y, we must for the greatest probability, have the equation $\frac{x}{a}=\frac{y}{b}$. Let X and Y be similar functions of a, x, and of b, y, expressing the probabilities that the errors x, y happen in the distances a, b; and, by the

fundamental principle of the doctrine of chance, the probability that both these errors happen together will be expressed by the product XY. If now we were to determine the values of x and y from the equations $x+y=\mathrm{E}$ and $\mathrm{XY}=$maximum, we ought evidently to arrive at the equation $\frac{x}{a}=\frac{y}{b}$: and since x and y are rational functions of the simplest order possible of a, b and E, we ought to arrive at the equation $\frac{x}{a}=\frac{y}{b}$ without the intervention of roots, in other words by simple equations; or, which amounts to the same thing in effect, if there be several forms of X and Y that will fulfill the required condition we must choose the simplest possible, as having the greatest possible degree of probability.

"Let X′, Y′ be the logarithms of X and Y, to any base or modulus; and when $\mathrm{XY}=max.$ its logarithm $\mathrm{X}'+\mathrm{Y}'=max.$ and therefore $\dot{\mathrm{X}}'+\dot{\mathrm{Y}}'=0$, which fluxional equation we may express by $\mathrm{X}''\dot{x}+\mathrm{Y}''\dot{y}=0$; for as X′ involves only the variable quantity x, its fluxion $\dot{\mathrm{X}}'$ will evidently involve only the fluxion of x; in like manner the fluxion of Y′ may be expressed by $\mathrm{Y}''\dot{y}$; and from the equation $\mathrm{X}''\dot{x}+\mathrm{Y}''\dot{y}=0$ we have $\dot{\mathrm{X}}''\dot{x}=-\mathrm{Y}''\dot{y}$: but since $x+y=\mathrm{E}$ we have also $\dot{x}+\dot{y}=0$, and $\dot{x}=-\dot{y}$, by which dividing the equation $\dot{\mathrm{X}}''\dot{x}=-\dot{\mathrm{Y}}''\dot{y}$, we obtain $\mathrm{X}''=\mathrm{Y}''$.

"Now this equation ought to be equivalent to $\frac{x}{a}=\frac{y}{b}$; and this circumstance is effected in the simplest manner possible, by assuming $\mathrm{X}''=\frac{mx}{a}$, and $\mathrm{Y}''=\frac{my}{b}$; m being any fixed number which the question may require.

"Since, therefore, $\mathrm{X}''=\frac{mx}{a}$ we have $\mathrm{X}''\dot{x}=\dot{\mathrm{X}}'=\frac{mx\dot{x}}{a}$, and taking the fluent, we have $\mathrm{X}'=a'+\frac{mx^2}{2a}$. The constant quantity a' being either absolute, or some function of the distance a.

"We have discovered, therefore, that the logarithm of the probability that the error x happens in the distance a is expressed by $a'+\frac{mx^2}{2a}=\mathrm{X}'$, and consequently the probability itself is $\mathrm{X}=e^{\mathrm{X}'}=e^{\left(a'+\frac{mx^2}{2a}\right)}$. Such is the formula by which the probabilities of different errors may be compared, when the values of the determinate quantities e, a' and m are properly adjusted. If this probability of the error x be denoted

by u, the ordinate of a curve to the abscissa x, we shall have $u = e^{\left(a' + \frac{mx^2}{2a}\right)}$, which is the general equation of *the curve of probability.*

"When only the maximum of probability is required, we have no need of the values of e, a' and m; it is proper, however, to observe that m must be negative. This is easily shown. The probability that the errors x, y, z, etc., happen in the distances a, b, c, etc., is $e^{\left(a' + \frac{mx^2}{2a}\right)} \times e^{\left(b' + \frac{my^2}{2b}\right)} \times e^{\left(c' + \frac{mz^2}{2c}\right)}$, etc., which is equal to $e^{\left(a'+b'+c', \text{ etc.}, + \frac{mx^2}{2a} + \frac{my^2}{2b} + \frac{mz^2}{2c}, \text{etc.}\right)}$, and this quantity will evidently be a maximum or minimum as its index or logarithm is a maximum or minimum; that is, when

$$\frac{m}{2}\left\{\frac{x^2}{a} + \frac{y^2}{b} + \frac{z^2}{c}, \text{ etc.}, \right\} = \text{a maximum or minimum.}$$

Now when $x + y + z$, etc., $= E$, we know that

$$\frac{x^2}{a} + \frac{y^2}{b} + \frac{z^2}{c}, \text{ etc.}, = \text{minimum, when } \frac{x}{a} = \frac{y}{b} = \frac{z}{c}, \text{ etc.},$$

and therefore $-\left\{\frac{x^2}{a} + \frac{y^2}{b} + \frac{z^2}{c}, \text{ etc.}, \right\} = \text{maximum.}$

When $\frac{x}{a} = \frac{y}{b} = \frac{z}{c}$, etc., it is evident therefore that m must be negative; and as we may for the case of maxima use any value of it we please, we may put $m = -2$, and the probability of x in a is $u = e^{\left(a' - \frac{x^2}{a}\right)}$. If we put $\frac{m}{2a} = -1$ and $a' = f^2$, we have $u = e^{(f^2 - x^2)}$ for the equation of the curve of probability; but if we suppose $f^2 = 0$, the ordinates u will still be proportional to their former values, and we shall have $u = e^{-x^2}$, or $u = \frac{1}{e^{x^2}}$, which is the simplest form of the equation expressing the nature of the curve of probability."

Immediately following the above general solution by Dr. Adrian there are given applications of this method to the following problems.

1. To find the most probable value of any quantity of which a number of direct measures are given.
2. To find a most probable position of a point in space.
3. To correct in the most probable manner the dead reckoning at sea.
4. To correct the bearing and distances of a field survey.

The article closes on p. 109 of the Analyst with the following:

"I have applied the principles of this essay to the determination of the most probable value of the earth's ellipticity, &c., but want of room will not permit me to give the investigation at this time."

The investigations here alluded to were, however, long afterwards published, i. e., in 1817, in vol. i, new series, of the Transactions of the American Philosophical Society, and are given in two papers (Nos. IV and XXVIII) of that volume. The preceding note as well as the dates written on the manuscripts (which are still preserved by the Hon. G. B. Adrian of New Brunswick) show that these two investigations were completed in 1808.

The first of the papers here alluded to is entitled "Investigation of the figure of the earth and of the gravity in different latitudes," from which as printed in the Phil. Trans., we make the following extract:

"Having in the year 1808 discovered a general method of resolving several useful problems by ascertaining the highest degree of probability, when certainty cannot be found, I shall here apply that method to the determining of the earth's ellipticity, &c." The author's computation is based on the lengths of the seconds pendulum as given by Laplace (Mec. Cel., iii), and having stated the problem before him, he says: "This is accomplished by a rule published by the writer in the Analyst, in 1808." The resulting ellipticity ($\frac{1}{3}\frac{1}{1}\frac{1}{5}$) he shows to differ from that deduced by Laplace ($\frac{1}{3}\frac{1}{0}\frac{1}{8}$) because of numerical errors in the computation of the latter; having corrected these he deduces the ellipticity $\frac{1}{3}\frac{1}{0}\frac{1}{9}\cdot\frac{5}{3}$ by Laplace's own method—showing that the two methods conduce to nearly the same result.

The second of the articles in the Phil. Trans., is entitled "A Research concerning the Mean Diameter of the Earth." In this the author seeks the sphere which most nearly coincides in various specified peculiarities with the actual terrestrial spheroid; the diameter of this sphere he determines to be 7918·7 miles. This numerical result is based upon some earlier computations, the details of which are not given, but of which he says: "Having determined the most probable axis of the terrestrial spheroid from the measurements of a degree of the meridian by a method which I discovered several years ago and published in the Analyst, the resulting mean radius was found to be 3959·69 English miles."

The mathematical works published by Dr. Adrian are so rarely to be met with, that it was necessary to make these long extracts in order to establish the conclusion to which we have arrived, i. e., that we must credit Dr. Adrian with the independent invention and application of the most valuable arithmetical process that has been invoked to aid the progress of the exact sciences.

Washington, Feb. 22, 1871.

ART. LX.—*Contributions to Chemistry from the Laboratory of the Lawrence Scientific School.* No. 15.—*On some new Analytical Methods;* by THOMAS M. CHATARD.

§ 1. *On the Determination of Molybdic Acid as Plumbic Molybdate.*

GREAT difficulty has always been experienced in determining molybdenum by any of the methods generally in use. The precipitation as mercurous molybdate, and the subsequent treatment, are both tedious and unsatisfactory, and an accurate determination as sulphide is almost impossible, the filtrate remaining blue even after repeatedly passing sulphydric acid and filtering.

The following method will, I hope, be found to give satisfaction, both as to ease of working and accuracy of results.

Add to the boiling solution of the molybdate, plumbic acetate in slight excess. Boil for a few minutes; the precipitate, at first milky, will become granular and will subside easily, leaving a perfectly clear supernatant liquid. Care must be taken in boiling, as the thick milky fluid is very apt to boil over. A ribbed filter is to be used and the precipitate is to be washed with hot water. The washing proceeds with great ease and thoroughness, and not the slightest milkiness should be apparent in the filtrate. The precipitate is dried at 100°, separated from the filter and ignited in a porcelain crucible.

The results were as follows:

1·0744	grm.	Na_2MoO_4	gave	1·9176	grm.	$PbMoO_4$	=	46·64	p. c.	Mo.
1·4440	"	"	"	2·5738	"	"	=	46·60	"	"
1·2221	"	"	"	2·1811	"	"	=	46·66	"	"
1·2871	"	"	"	2·2999	"	"	=	46·74	"	"

Mean = 46·66.

The theoretical percentage of Mo in Na_2MoO_4 is 46·60 if Mo = 96, this being the number given by the most recent determinations.

The process seems therefore to give very good quantitative results, and is both easy and expeditious. The precipitated molybdate separates easily from the filter and can be heated to low redness without decomposition.

Analogy would seem to offer a good method for tungstic acid and experimental analyses were made for this purpose, but after repeated trials the process was finally abandoned, as the precipitate came down so finely divided that it passed through the filter. The precipitation seems, however, to be complete, and I have hopes that with closer filter paper greater success will be obtained.

Attempts were made to determine arsenic as arsenate of lead but without good quantitative results. On the other hand

I tried to determine lead as molybdate, tungstate, and arsenate, but without success, as the presence of an excess of the precipitant in such cases seems to exert an injurious effect, the filtrate or washings speedily becoming cloudy.

It may not be out of place to mention some work upon molybdenum undertaken some time ago, which, though unsuccessful, is not without interest. Various methods were devised of weighing the molybdenum as sulphide.

One way was to precipitate molybdic acid as mercurous molybdate in the usual manner. The suspended molybdate was boiled and sulphydric acid passed into the boiling liquid. The mercurous molybdate was decomposed and mercurous sulphide and molybdic sulphide were the results. The sulphides were thrown upon a filter and washed with cold sulphydric acid water, dried and ignited in a current of sulphydric acid, but this process failed to give satisfactory results.

Again, sodic molybdate was heated with four parts of dry sodic hyposulphite till all the free sulphur was driven off, leaving, according to theory, $Na_2SO_4 + MoS_3$. The mass was then digested with hot water, filtered and treated as before. When any of the sulphur was left, it was found that some of the molybdenum went into solution as sulphomolybdate of sodium. Even after adopting every precaution, enough was still dissolved to vitiate the analysis.

§ 2. *On the Evaporation to dryness of Gelatinous Precipitates.*

In a former paper * I called attention to the fact that many gelatinous precipitates, when evaporated to dryness, became very granular and easy to filter. I gave some examples then and have since tested several others.

Titanic Acid.—Rutile was fused with sodic disulphate, the titanic acid precipitated by ammonic hydrate and evaporated to dryness. It became quite sandy and washed with great rapidity and thoroughness.

Glucina.—Pure glucina was dissolved in chlorhydric acid, precipitated by ammonic hydrate and evaporated to dryness. In this case as glucina is soluble in ammoniacal salts, it was necessary to ignite the dry mass to expel these. This was done in the platinum dish in which the evaporation was carried on. The residual glucina was sandy and washed with great ease; *zirconic*, *niobic* and *tantalic acids* when thus treated gave results which were all that could be desired.

Ceric, lanthanic and didymic oxalates when treated with sulphuric acid, and ammonic hydrate added, gave also perfectly satisfactory results.

* This Journal, vol. l, p. 247.

In conclusion, there seems to be no doubt that almost any gelatinous precipitate can be successfully treated in this manner.

§ 3. *Tests for Nitrous Acid.*

During the course of some work on the nitrites of nickel and cobalt, it was necessary to have an easy and accurate test for nitrous acid. I therefore reviewed all the tests given for that acid, comparing their relative degrees of delicacy, with the following results. For testing, a very dilute solution of Fischer's salt, $(Co_2 6NO_2 + 6(KNO_2) + 2Aq)$, which contained $\frac{1}{2000}$ part by weight of nitrous acid, was employed.

Schönbein's* test with a weak solution of indigo decolorized by potassic sulphide failed to give accurate results. Besides there are many substances which would have the same action upon the decolorized indigo as the nitrous acid.

C. D. Braun's† test with cobaltous chloride and potassic cyanide gave no reaction with so dilute a solution, even when several cubic centimeters were taken, the reaction only appearing when a comparatively strong solution of the nitrite was used.

Hadow's‡ reaction in which a nitrite when heated with potassic ferrocyanide and mercuric chloride forms nitroprussic acid which is detected by an alkaline sulphide, gave good results only when the nitrous acid was present in larger quantities, not being delicate enough to give a reaction with the standard solution of nitrite which I employed.

A modification of this test suggested itself, in which the nitroprussic acid is thus produced. To the solution suspected of containing the acid, potassic ferrocyanide and acetic acid are added, and the whole boiled. The solution is allowed to cool, and ammonic sulphide added. If nitrous acid was originally present, the characteristic blue reaction will appear. 10 c.c. of the test solution gave the reaction, but it failed with a smaller quantity.

The problem was finally solved by another reaction, namely, the production of phenol from aniline by means of nitrous acid. Evaporate the test liquid nearly to dryness, then rub it with a few drops of a strong solution of sulphate of aniline. If nitrous acid is present the odor of phenol will immediately result. This test is remarkably delicate, 1 c. c. of the test solution giving a perfectly distinct reaction. Nor can nitrous be confounded with nitric acid, as this last produces no phenol, but merely a yellow color, which of itself, as is well known, is of value as a test for that acid.

* Jahresbericht, 1864, 699.

† Ibid. 1865, 702.

‡ Jour. Chem. Soc., vol. iv, p. 341.

§ 4. *On the Determination of small quantities of Manganese.*

The delicacy of Crum's test for manganese is well known, but it is believed that no attempt has hitherto been made to employ it as a method of quantitative determination. The following work was, therefore, undertaken with that view.

A standard solution of ammonic oxalate was prepared, of which 1 c. c. = 0·0005467 grm. Mn. A sample of dolomite was taken, and four portions were weighed out. These were dissolved in nitric acid, and a small quantity of plumbic peroxide added to each. On boiling, the bright color of hypermanganic acid appeared. The solutions were passed through small filters of asbestos with the aid of a Bunsen's pump, and the hypermanganic acid was determined by means of a standard solution of ammonic oxalate with the following results:

3·1300 grm. dolomite	required	39·0 c. c.	=	0·0216 grm.	Mn	=	00·069 p. c.	Mn
2·781 " "	"	33·2 "	=	0·0181 "	"	=	00·065 "	"
2·0998 " "	"	24·5 "	=	0·0134 "	"	=	00·063 "	"
1·8671 " "	"	23·5 "	=	0·0128 "	"	=	00·062 "	"

Mean = 00·065 p. c. Mn.

In a sample of limestone from White Horse, Chester, Co., Pa. the analysis showed

3·4316 grm.	required	120 c. c.	=	0 0656 grm.	Mn	=	1·92 p. c.	Mn
2·2809 "	"	83·5 "	=	0·04564 "	"	=	2·00 "	"
4·0697 "	"	153·5 "	=	0·0838 "	"	=	2·05 "	"

Mean = 1·99 p. c. Mn.

But the method, though giving good results where the percentage of manganese is small, fails when any large amount of that metal is present. Well dried manganous pyrophosphate was treated with sulphuric acid, as nitric acid, though dissolving it, was found not to decompose it, little or no hypermanganic acid being formed when the plumbic peroxide was added. With sulphuric acid, the red color of hypermanganic acid was produced, but it was found that not even long boiling sufficed for total oxydation.

This was also the case with an alloy of iron and manganese. The longer it was boiled, the more hypermanganic acid was formed, but there seemed to be no definite limit. No concordant results having been reached, and a well marked end reaction in such cases being hard to obtain, the method as applied to general analysis was given up.

There seems to be, however, reason to maintain that when the quantity of manganese is very small, the method will be found both easy and accurate. Perhaps by some modification of the process, it may be made to apply also to the cases in which large quantities of manganese are present.

In conclusion, I desire to acknowledge my indebtedness to Dr. W. Gibbs for his careful supervision and many valuable suggestions.

Cambridge, March 1, 1871.

ART. LXI.—*On the Oil-bearing Limestone of Chicago;* by T. STERRY HUNT, LL.D., F.R.S.

(Read before the American Association for the Advancement of Science at Troy, August, 1870.)

WHEN in 1861,* I first published my views on the petroleum of the West, I expressed the opinion that the true source of it was to be looked for in certain limestone formations which had long been known to be oleiferous. I referred to the early observations of Eaton and Hall on the petroleum of the Niagara limestone, to numerous instances of the occurrence of this substance in the Trenton and Corniferous formations and, in Gaspé, in limestones of Lower Helderberg age. Subsequently, in this Journal for March, 1863, and in the Geology of Canada, I insisted still further upon the oleiferous character of the Corniferous limestone in southwestern Ontario, which appears to be the source of the petroleum found in that region. I may here be permitted to recapitulate some of my reasons for concluding that petroleum is indigenous to these limestones, and for rejecting the contrary opinion, held by some geologists, that its occurrence in them is due to infiltration, and that its origin is to be sought in an unexplained process of distillation from pyroschists or so-called bituminous shales. These occur at three distinct horizons in the New York system, and are known as the Utica slate, immediately above the Trenton limestone, and the Marcellus and Genesee slates which lie above and below the Hamilton shales; the latter being separated from the underlying Corniferous limestone by the Marcellus slate.

First, these various pyroschists do not, except in rare instances, contain any petroleum or other form of bitumen. Their capability of yielding volatile liquid hydrocarbons or pyrogenous oils, allied in composition to petroleum, by what is known to chemists as destructive distillation, at elevated temperatures, is a property which they possess in common with wood, peat, lignite, coal, and most substances of organic origin, and has led to their being called bituminous, although they are not in any proper sense bituminiferous. The distinction is one which will at once be obvious to all those who are familiar with chemistry, and who know that pyroschists are argillaceous rocks containing in a state of admixture a brownish insoluble and infusible hydrocarbonaceous matter, allied to lignite or to coal.†

Second, the pyroschists of these different formations do not, so far as known, in any part of their geological distribution, whether exposed at the surface or brought up by borings from

* Montreal Gazette, March 1, and Can. Naturalist, July, 1861.

† This Journal, II, xxxv, 159–161.

depths of many hundred feet, present any evidence of having been submitted to the temperature required for the generation of volatile hydrocarbons. On the contrary they still retain the property of yielding such products when exposed to a sufficient heat, at the same time undergoing a charring process by which their brown color is changed to black. In other words these pyroschists have not yet undergone the process of destructive distillation.

Third, the conditions which the oil occurs in the limestones, are inconsistent with the notion that it has been introduced into these rocks by distillation. The only probable or conceivable source of heat, in the circumstances, being from beneath, the process of distillation would naturally be one of ascension, the more so as the pores of the underlying strata would be filled with water. Such being the case, the petroleum of the Upper Silurian and Lower Devonian limestones must have been derived from the Utica slate beneath. This rock, however, is unaltered, and moreover, the intermediate sandstones and shales of the Loraine, Medina and Clinton formations are destitute of petroleum, which must, on this hypothesis, have passed through all these strata to condense in the Niagara and the Corniferous limestones. More than this, the Trenton limestone which, on Lake Huron and elsewhere, has yielded considerable quantities of petroleum, has no pyroschists beneath it, but on Lake Huron rests on ancient crystalline rocks, with the intervention only of a sterile sandstone. The rock-formations holding petroleum are not only separated from each other by great thicknesses of porous strata destitute of it, but the distribution of this substance is still further localized, as I many years since pointed out. The petroleum is in fact in many cases, confined to certain bands or layers in the limestone, in which it fills the pores and the cavities of fossil shells and corals, while other portions of the limestone, both above, below, and in the prolongation of the same stratum, though equally porous, contain no petroleum. From all these facts the only reasonable conclusion seems to me to be that the petroleum, or rather the materials from which it has been formed, existed in these limestone rocks from the time of their first deposition. The view which I put forward in 1861, that petroleum and similar bitumens have resulted from a peculiar "transformation of vegetable matters, or in some cases of animal tissues analogous to these in composition," has received additional support from the observations of Lesley,* in West Virginia and Kentucky, and from the more recent ones of Peckham.†

* Rep. Geol., Canada, 1866, 240, and Proc. Amer. Philos. Soc., x, 33, 187.
† Ibid, x, 445.

The objections to this view of the origin and geological relations of petroleum have been for the most part founded on incorrect notions of the geological structure of southwestern Ontario, which has afforded me peculiar facilities for studying the question. In this region, it has been maintained by Winchell that the source of the petroleum is to be sought in the Devonian pyroschists. I however showed in 1866, as the result of careful studies of the various borings: first, that none of the oil-wells were sunk in the Genesee slates, but along denuded anticlinals where these rocks have disappeared, and where, except the thin layer of Marcellus slate sometimes met with at the base of the Hamilton shales, no pyroschists are found above the Trenton limestone. Second, that the reservoirs of petroleum in the wells sunk into the Hamilton shales are sometimes met with in this formation, and sometimes, in adjacent borings, only in the underlying Corniferous. Examples of this have been cited by me in wells in Enniskillen, Bothwell, Chatham and Thamesville, where petroleum has first been found at depths of from thirty to one hundred and twenty feet in the Corniferous limestone, in all of these places overlaid by the Hamilton shales. It was also shown, that in two localities in this region, viz., at Tilsonburg and in Maidstone, where the Corniferous is covered only by quaternary clays, petroleum in considerable quantities has been obtained by sinking into the limestone.* That the supplies of petroleum in such localities are less abundant than in parts where a mass of shales and sandstones overlies the oil-bearing limestone is explained by the fact that both the pores and the fissures in the superior strata serve to retain the oil, in a manner analogous to the quaternary gravels in some parts of this region, which are the sources of the so-called surface oil-wells. It is, therefore, not surprising that examples of pyroschists impregnated with oil should sometimes occur, but the evidence of the existence of indigenous petroleum, which is so clear in the various limestones, is wanting in the case of the pyroschists; although concretions holding petroleum, have been observed in the Marcellus and the Genesee slates of New York. There is, however, reason to believe, as I have elsewhere pointed out, that much of the petroleum of Pennsylvania, Ohio, and the adjacent regions, is indigeneous to certain sandstone strata in the Devonian and Carboniferous rocks.†

At the meeting of the American Association for the Advancement of Science at Chicago, in August, 1868, in a discussion which followed the reading of a paper by myself on the geology of Ontario,‡ it was contended that, although the

* This Jour. II, xlvi, 360; and Report Geol., Canada, 1866, pp. 241–250.
† Ibid. 240.
‡ This Jour. II, xlvi, 355.

various limestones which have been mentioned are truly oleiferous, the quantity of petroleum which they contain is too inconsiderable to account for the great supplies furnished by oil-producing districts, like that of Ontario for example. This opinion being contrary to that which I had always entertained, I resolved to submit to examination the well-known oil-bearing limestone of Chicago.

This limestone, the quarries of which are in the immediate vicinity of the city, is so filled with petroleum that blocks of it which have been used in buildings are discolored by the exudations, which mingled with dust, form a tarry coating upon the exposed surfaces. The thickness of the oil-bearing beds, which are massive and horizontal, is, according to Prof. Worthen, from thirty-five to forty feet, and they occupy a position about mid-way in the Niagara formation, which has in this region a thickness of from 200 to 250 feet. As exposed in the quarry, the whole rock seems pretty uniformly saturated with petroleum, which exudes from the natural joints and the fractured surfaces, and covers small pools of water in the depressions of the quarry. I selected numerous specimens of the rocks from different points and at various levels, with a view of getting an average sample, although it was evident that they had already lost a portion of their original content of petroleum. After lying for more than a year in my laboratory they were submitted to chemical examination. The rock, though porous and discolored by petroleum, is, when freed from this substance, a nearly white, granular, crystalline and very pure dolomite, yielding 54·6 p. c. of carbonate of lime.

Two separate portions, each made up of fragments obtained by breaking up some pounds of the specimens above mentioned, and supposed to represent an average of the rock exposed in the quarry, were reduced to coarse powder in an iron mortar. Of these two portions, respectively, 100 and 138 grammes were taken, and were dissolved in warm dilute hydrochloric acid. The tarry residue which remained in each case, was carefully collected and treated with ether, in which it was readily soluble with the exception of a small residue. This, in one of the samples, was found equal to ·40 p. c., of which ·13 was volatilized by heat with the production of a combustible vapor having a fatty odor; the remainder was silicious. The brown etherial solutions were evaporated, and the residuum, freed from water and dried at 100° C., weighed in the two experiments equal to 1·570 and 1·505 per cent of the rock, or a mean of 1·537. It was a viscid reddish-brown oil, which, though deprived of its more volatile portions, still retained somewhat of the odor of petroleum, which is so marked in the rock. Its specific gravity, as determined by that of a mixture of alcohol and water, in which the globules of the petroleum remained

suspended, was ·935 at 16° C. Estimating the density of the somewhat porous dolomite at 2·600, we have the equation ·935 : 2·600 :: 1·537 : 4·26; so that the volume of the petroleum obtained equalled 4·26 per cent of the rock. This result is evidently too low for two reasons; first, because the rock had already lost a part of its oil, while in the quarry and subsequently, before its examination: and secondly, because the more volatile portions had been dissipated in the process of extraction just described.

In assuming 100·00 parts of the rock to hold 4·25 parts by volume of petroleum, we are thus below the truth in the following calculations. A layer of this oleiferous dolomite one mile (5280 feet) square, and one foot in thickness will contain 1,184,832 cubic feet of petroleum, equal to 8,850,069 gallons of 231 cubic inches, and to 221,247 barrels of forty gallons each. Taking the minimum thickness of thirty-five feet, assigned by Mr. Worthen to the oil-bearing rock at Chicago, we shall have in each square mile of it 7,743,745 barrels, or in round numbers seven and three quarter millions of barrels of petroleum. The total produce of the great Pennsylvania oil-region for the ten years from 1860 to 1870 is estimated at twenty-eight millions of barrels of petroleum, or less than would be contained in four square miles of the oil-bearing limestone band of Chicago.

It is not here the place to insist upon the geological conditions which favor the liberation of a portion of the oil from such rocks, and its accumulation in fissures along certain anticlinal lines in the broken and uplifted strata. These points in the geological history of petroleum were shown by me in my first publications already referred to, March and July, 1861, and independently, about the same time, by Prof. E. B. Andrews in this Journal for July, 1861.*

The proportion of petroleum in the rock of Chicago may be exceptionally large, but the oleiferous character of great thickness of rock in other regions is well established, and it will be seen from the above calculations that a very small proportion of the oil thus distributed would, when accumulated along lines of uplift in the strata, be more than adequate to the supply of all the petroleum wells known in the regions where these oil-bearing rocks are found. With such sources existing ready formed in the earth's crust, it seems to me, to say the least, unphilosophical to search elsewhere for the origin of petroleum, and to imagine it to be derived by some unexplained process from rocks which are destitute of the substance.

* This Journal II, xxxii, 85. See also papers on the subject by him and by Prof. Evans, Ibid. II, xl. 33, 334; and one by the author, II, xxxv, 170; also Report Geol. Survey of Canada, 1866, pp. 256–257.

ART. LXII.—*On the Geology of the Delta, and the Mudlumps of the Passes of the Mississippi;* by EUG. W. HILGARD.

[Continued from page 368.]

Origin of the Mudlumps.—The causes which give rise to the formation of mudlumps have been to some extent discussed by Sidell, Thomassy, and Lyell (*loc. cit.*). The former is inclined to ascribe the upheaval *chiefly* to the pressure of gas formed in the decay of driftwood and the like, buried in the river deposits. Thomassy resorts to the hypothesis of the existence of subterraneous channels communicating with the river, or with equally hypothetical reservoirs of water, far above; while Lyell ascribes the bulging of the bottom to the pressure of newly formed deposits upon a substratum of yielding mud, accompanied, and aided incidentally only, by the evolution of marsh gas in the decay of organic matter. I myself, having become aware of the existence of a strong artesian water pressure in the littoral formations of the Gulf, was inclined to ascribe the origin of the upheaving force to that source; and my visit to the mouths had for its object mainly, the comparison of the facts with each of the three admissible hypotheses, that of Thomassy being too fanciful to be seriously entertained.

As already stated, I at once found that the evolution of gas in the active vents was too insignificant to be considered as the cause of the rising of the liquid mud, which so greatly exceeded it in bulk, that the ascensional force of the bubbles, especially in so wide a vent-tube, would be utterly inadequate to balance the downward tendency of so heavy a liquid. It might still be alleged, in favor of the gas-hypothesis, that its pressure might be exerted statically upon the surface of the mass of liquid mud covered by impervious strata; but it is obvious that in such a case, the gas itself, necessarily accumulating at the highest, and therefore weakest, points, of the superincumbent mass, would be much more likely to break through by itself, promptly exhausting its force and quantity at any one point. No such rushing outbreaks of gas have ever been recorded, save in the case of blowing up of a lump with gunpowder; and, as Lyell remarks, this view renders inexplicable the occurrence of lumps exclusively about the mouths of the passes.

The latter objection applies equally to the hypothesis of the artesian origin of mudlump force, unless upon the (unproved) supposition that the excavation of the river channel might have rendered the outbreak of the artesian water easier there than elsewhere. But instead of *excavating*, the Mississippi has for a long time past always thrown *shallows* in advance of its

mouths; and unless it were conclusively proven that *the matters ejected by the mud-springs* were such as could not originate in the present delta formation, the artesian hypothesis must lose all show of probability. An accurate investigation of the matters in question, solid, liquid, and gaseous, was therefore indicated. A few specimens for this purpose were collected for me by Mr. Marindin, in 1867; but the perusal of his report accompanying them convinced me that a personal examination *in loco* could alone insure a perfect certainty as to their significance, and accordingly, in the autumn of the same year, I re-collected specimens from the same, as well as from other localities. Very unfortunately, the arrangements for gas analysis at my command were so imperfect that, while waiting for their improvement, the gas specimens were so vitiated by diffusion through corks and wax as to render them useless; and I have been unable to replace them as yet, but hope to do so in the near future.

Mudlump Gases.—The examination of the water and mud seemed, however, most likely to conduce to a solution of the problem, at any rate; for after all, the only information which could be furnished by gas analysis would be to indicate, by the greater or less amount of carbonic acid present, whether the gas originated from matter comparatively fresh and in its first stage of decomposition, or had its source in materials far advanced toward the stage of lignite or coals. The only perfectly reliable determination made was that of the carbonic acid contained in the gas collected from the most easterly active cone on Marindin's Lump, Passe à l'Outre, the rest of the determinations being somewhat vitiated, though doubtless very nearly correct.* The result was as follows:

Gas from East Crater, Marindin's Lump, Passe à l'Outre.

Carbonic acid,	9·41
Marsh gas,	86·20
Nitrogen,	4·39
	100·00

Oxygen was not present.

The percentage of carbonic acid in this gas is very unusually large; its composition is nearest to that of the gas from common swamps, where vegetable matter is in its first stages of decay. The proportion between marsh gas and nitrogen is nearly the same as in the gas from the gas wells at New Orleans (see p. 245): but there is three times as much carbonic acid present

* After the explosion in the eudiometer, some nitrate of mercury was observed on its walls, in consequence of inadequate dilution of the gas. But the marsh gas was estimated from the carbonic acid absorbed after the explosion, the nitrogen by difference.

in the mud-lump gas, in accordance with the presumable more advanced stage of decay existing in the former locality.

Mudlump Spring Waters.—In taking specimens, common quart bottles were filled by immersion in the craters themselves, and immediately sealed. The liquid mud thus obtained would, after a while, separate into a lower stratum of pretty solid mud, and an upper one of clear water, in varying proportions. For analysis, the latter was carefully decanted, and the turbid part rapidly filtered through a Bunsen's pressure filter, and measured. 400 ccm. were then boiled to precipitate carbonates and silica, the filtrate re-diluted to the original bulk, and from 50 to 100 ccm. used in the determination, in separate portions, of chlorine, of lime and magnesia, and of sulphuric acid and alkalies, respectively; while a fourth portion served for an approximate determination of the solid residue, for the sake of roughly controlling the final results.*

I give below, in tabular form, the results of these analyses; presented in three different forms, for the sake of ready comparison with the composition of sea-water, from which they seem to be derived by a series of reactions easily understood from the nature and condition of the materials with which they are associated.

I. Water from the basin of a spring on a mudlump off Stake Island, Southwest Pass. Evolves gas and water in about equal proportions, no mud, but only fine sandy matter; and water flows off clear over the rim of the basin, which is two feet above tide level, and at the foot of a large extinct cone with a lagoon, surrounded by a high rim, in the center.

Water about $\frac{1}{4}$ of the bulk in bottle, the rest fine sand. Taste, very salty; color, slightly yellowish; turns brownish turbid very quickly on exposure to air. Coll. Dec. 3, 1867.

II. Water from a mudlump spring on Northeast Pass, collected by H. L. Marindin, of U. S. Coast Survey schr. Varina, in February, 1867.

According to the recollection of one of the crew, this specimen was taken from the same cone as the following one (No. III).

Water clear, faintly yellowish, about $\frac{1}{4}$ by bulk of the contents; the rest sandy mud. Turns turbid rapidly on exposure to air.

* With mixtures of this kind no method but that of evaporation with excess of carbonate of soda will yield anything more than an approximate estimate of the solid residue; involving an amount of labor and care not always justified by the end in view, when the relative amounts of ingredients can serve to control. The chlorine determination being the most accurate, and almost always in excess of the bases found available to form chlorides, the chloride of sodium, as here recorded, is the *calculated* amount, as is also the sum of ingredients.

Analyses of Waters from Mudlump Springs, Mississippi Passes.

	Southwest Pass. I.			Northeast Pass. Salt Spring Island. February. II.			December. III.			Passe à l'Outre. Marindin's Lump. East Crater. IV.			West Crater. V.		
	a.	b.	c.	a.	b.	c.	a.	b.	c.	a.	b.	c.	a.	b.	c.
Chloride of Sodium,	2·5374	80·060	81·662	2·7847	81·937	84·117	2·7751	82·809	84·670	1·2439	79·094	85·857	1·7544	79·708	84·055
" Potassium,	0·0280	0·884	0·901	0·0441	1·297	1·332	0·0441	1·316	1·346				0·0166	0·754	0·795
" Calcium,	0·0725	2·287	2·388	0·0342	1·006	1·033	0·0638	1·903	1·947	0·0018	0·114	0·124	0·0649	2·947	3·109
" Magnesium,	0·4635	14·624	14·917	0·4475	13·168	13·518	0·3945	11·773	12·037	0·1962	12·475	13·543	0·1259	11·440	12·061
Sulphate of Calcium,	0·0007	0·022	0·023							0·0069	0·439	0·476			
" Magnesium,															
Carbonate of Calcium,	0·0011	0.035		0·0313	0·921		0·0001	0·003		0·0695	4·419		0·0230	1·045	
" Magnesium,	0·0446	1.407		0·0447	1·315		0·0724	2·160		0·0392	2·492		0·0745	3·385	
" Iron,	0·0158	0,499		0·0121	0·356					0·0119	0·757		0·0128	0·582	
Silica,	0·0007	0.022					0·0012	0·036		0·0033	0·210		0·0030	0·139	
	3·1643	99·840	99·891	3·3986	100·000	100·000	3·3512	100·000	100·000	1·5727	100·000	100·000	2·2010	0·06100	100·000
Specific Gravity,		1·02388			1·0244						1·01196			1·01689	

a. Ingredients in 100 ccm. of the water. b. Ingredients in 100 parts of solid residue. c. Ingredients in 100 parts of solid residue exclusive of carbonates and silica.

TABLE—continued.

	Knight's Gas Well. New Orleans. VI.			Gulf Water. 30 miles out. VII.		Sea Water. Average composition. VIII.	
	a.	b.	c.	a.	b.	a.	b.
Chloride of sodium,	0·02310	37·880	56·479	1·6723	76·870	2·700	77·032
" potassium,	0·00790	12·950	19·315	0·0357	1·640	0·070	1·997
" calcium,	0·00060	0·980	1·467				
" magnesium,	0·00630	10·330	15·404	0·2310	10·620		10·271
Sulphate of calcium,						0·360	
Bromide of magnesium,				trace.	trace.	0·002	0·058
Sulphate "	0·00300	4·920	7·335	0·1077	4·950	0·140	3·994
				0·1289	5·920	0·230	6·562
Carbonate of calcium,	0·01120	18·360				0·003	0·086
" magnesium,	0·00760	12·450					
" iron,							
Silica,	0·00130	2·130					
	0·06100	100·000	100·000	2·1756	100·000	3·505	100·000
Specific gravity,				1·01630		1·0298	

III. Water from faintly active cone on Salt Spring Island, off Northeast Pass; from crater on west side of island, about ten feet above sea-level. Collected Dec. 2, 1867.

Water very salty, about $\frac{3}{4}$ of the whole mass; the rest, a somewhat sandy mud; color, slightly yellowish; turns turbid rapidly on exposure to air.

The larger proportion of water in this specimen, as compared with the preceding, doubtless results from the comparative inactivity of the cone, as compared to that at the time of high water in February. The same fact may account for some of the difference in composition.

IV. Water from East Crater on Marindin's Lump, Passe à l'Outre. See p. 362. Collected Dec. 2, 1867.

Forms about $\frac{3}{5}$ of the bulk in the bottle, the rest is soft clayey mud. Faintly brownish, clear; becomes brownish turbid rapidly on exposure to air.

V. Water from West Crater on Marindin's Lump, Passe à l'Outre; same date.

Water about $\frac{1}{4}$ of bulk in bottle, the rest clayey mud. Not very salty; colorless, but turns turbid quickly on exposure to air.

VI. Water from gas well bored by J. B. Knight, at New Orleans. Clear, with a little sand at bottom; taste, faintly brackish.

VII. Water of the Gulf of Mexico, taken from surface 30 miles out, southeast from Southwest Pass, Dec. 1867.

VIII. Average composition of sea-water, according to Regnault.

The general results deducible from the above analyses may be thus stated:

1. There is a general similarity of composition between the waters of the mudlump springs, indicating their derivation from a common source of supply. But springs on the same lump, as well as the same spring at different times or stages of water, may vary quite sensibly, both in composition and concentration. Their density is generally inferior to that of sea-water, though at times approaching it closely.

2. There is an obvious approximation of the ratio between the two chief bases—sodium and magnesium—to that existing in sea-water; the variations being no greater than are observed in sea-water from different localities.

3. The most obvious difference is the absence of sulphates, and their partial replacement by chlorides; also

4. The presence of large amounts of the carbonates of the earths, as well as of iron, dissolved in carbonic acid.

5. The amount of potassium salts is decidedly diminished.

6. Bromids appear to be entirely absent, and are present in traces only, in the water of the Gulf itself.

It is stated that the waters of some of the springs are fresh. I have found all brackish *at least*, and as the population of the delta is much in the habit of drinking water of questionable freshness, their judgment in the matter may not be the most reliable.

As regards the water of the New Orleans well, though at first sight it differs materially from the others, it will be observed that when in C, potassium and sodium chlorides are classed together, its composition becomes not unlike the mudlump waters. Its great dilution accounts for the excessive proportion of carbonates.

The Gulf water approaches very closely in its composition to the normal one of sea-water, as given by Regnault.

Mud from Mudlump Springs.—I have already stated, that the stratified material of the mudlumps (whether formed by the action of mud springs, or bodily upheaved) is free from visible shells or other fossils, save particles of woody matter; while the amorphous material which forms the surface and generally also the beach, often abounds in such organic remains as are now usually washed ashore, having manifestly been *cast* up and imbedded in the mud by the waves.

I have examined microscopically the mud remaining in the specimen bottles after decanting the water for analysis; they were immediately refilled with distilled water, and kept closely stopped until examined. I give below the record of examination of the mud, corresponding to analysis No. V, from West Crater on Marindin's Lump. Two or three others similarly examined gave a like result.

A sample from the general mass shows it to consist mainly of very fine quartz sand, mostly angular, with but a few large, angular grains; and but little true clay.

In washing the mass, even the first washings were found to contain but little clay, but chiefly very fine suspended silex. A few ill defined spicules, a Navicula, and bark fibers.

In the middle portion, spicules a little more abundant.

In the coarsest portion, much variously colored mica, along with, mostly sharply angular, quartz grains; numerous particles of water-browned wood; very distinct spine of a radiate; several specimens of Rotalina, and fragments of same as well as Uvigerina, Cristellaria, Amphistegina, and Coccineis? Also iridescent fragments, showing lines of growth, from the edges of larger bivalves.

Quartz grains mostly transparent and angular; some of milky, oil-green, and rose quartz; these mostly rounded. This sand resembles closely that of the bottom outside Northeast Pass bar, in 40 to 50 feet water; specimens of which were furnished me by the Coast Survey party, under command of Capt. F. V. Webber of the schooner Varina, in 1869.

Specimens from mudlumps on Southwest Pass show coarser sand, and rather more Foraminifera.

The character of the materials ejected by the mudlump springs, as determined by the foregoing investigations, may be summed up as follows:

1. The *gas* is such as is evolved by vegetable matter in its *first* stages of decay or lignitization.

2. The *earthy matter* contains both river and marine fossils—driftwood reduced almost to its cell-elements by maceration and trituration, as well as Foraminifera. Its fineness is such that, before final deposition, it may have been carried out into water of considerable depth.

3. The mudlump waters appear to be sea-water more or less diluted, and chemically changed under the joint influence of fermenting organic matter, and the more active ingredients of the river deposit, viz: carbonates of lime and magnesia, and oxide of iron.

The first effect thus produced would probably be the addition of the soluble carbonates of these metals to the solution. But the soluble sulphates could not, in the presence of a soluble iron salt, long resist the reducing influence of decaying organic matter. As usual under such circumstances,* iron pyrites would be formed, withdrawing in the end all the sulphuric acid from the solution, and forming, instead, equivalent amounts of the respective carbonates. The amounts of the chlorides of

* See Bischoff, Chemische Geologie, vol. i, p. 559.

sodium and magnesium originally present would thus, also, be relatively increased; and this again tallies with the analytical results. Yet while the proportion between these bases is maintained* the actual *replacement* of sulphate of magnesium by the chloride constitutes a change not readily explained. At first sight it would seem that the excess of chlorine belonging to the chlorides of calcium and magnesium must be an outside accession; but our knowledge of the mutual reactions between the substances here present under strong pressure, is perhaps too fragmentary to justify an assertion on this point.

The diminution of the potash salts is doubtless referable to their absorption by the clays present, in preference to all other compounds. The filtration of sea-water through soil would, according to Liebig's experiments, produce a like result.

Conclusions.—In view of the foregoing facts, the explanation of mudlump phenomena suggested, substantially, by Sir Chas. Lyell, seems the only tenable one; it requires, however, some modification as regards the mass supposed to exert the pressure, and some corollaries as to the mode of action.

I have before suggested, that the rapid protrusion of the mouths of the river into the Gulf, in advance of the body of the delta, is owing to the shelf of "blue clay bottom" extending, at a comparatively slight depth below the sea-level, and with a gentle slope, far out into the Gulf. It is upon this impervious clay that the present bars are based; and upon it, in advance of the bar, will be deposited the finest of the river mud, at a depth at which, perhaps, the sea-water is at the time quite undiluted, and fully adapted to marine life; which will therefore deposit its vestiges in it, associated with the finest particles of driftwood, etc. Mud thus deposited may remain unconsolidated for a great length of time, unless the water be drained off or through it by some means.

The bar, in its annual advance of about 338 feet, will cover over this liquid mud stratum, exerting a pressure much greater than that of the sea; and were it resting on a pervious bottom, the liquid mud would doubtless soon be consolidated into a sheet of clay. As it is, the tendency will be to squeeze it from under the crest of the bar, both seaward and landward. The very gradual seaward slope of the bar will render the movement in that direction a very slow one, under a greater depth of water and heavy frictional resistence. Not so on the land side, where, as the bar advances, the superincumbent pressure is measurably relieved by the erosion of a channel by the

* The ratio is for

Atlantic sea-water,	30·5 : 3·0	Marindin's Lump water,	30·5 : 2·8 (min.)
German Ocean water,	30·5 : 4·0	Southwest Mudlump,	30·5 : 3·56 (max.)
Average sea "	30·5 : 3·4	Average of those analyzed,	30·5 : 3·1

current, which, especially in flood time, carries much of the bottom deposit bodily over the bar and drops it to seaward.* At weak points of the bottom inside the bar, therefore, the upward pressure of the mud may cause a bulging up at least to the level of the bar-crest, and, perhaps, taking into account the difference in the specific gravities of the comparatively solid bar and liquid mud, even as far as the surface of the water. But this, considering the question as coming within the domain of liquid statics, would seem to be about the extreme limit to which the bottom itself could be brought up.

I have found the specific gravity of the mud flowing from the West Crater on Marindin's Lump, to be about 1·25; that from the cone on Salt Spring Island, on Northeast Pass, 1·30; while that of bar deposit from the crest of the Northeast bar, wet as brought up by the lead, was 1·75. The heights of communicating columns of these substances, if sensibly liquid, should be as 5 to 7; but this ratio could apply, in the case of upheaval, only so far as the *difference* of level between the bar and the upheaved bottom is concerned, since the latter must be presumed to be similar to the bar in its materials and structure. Should the current, however, continue to denude the crest of the upheaved mass, the rising would continue and the semi-fluid mud might finally break through, forming a mudspring, the height of whose vent above its source might finally increase to the extent corresponding to the difference of specific gravity.

The craters of mudlumps have been sounded to the depth of 24 feet, but no precautions were used to insure reaching the actual maximum depth. In the borings made for the foundation of a lighthouse on the Southwest Pass, by Mr. A. Palms (the record of which was courteously forwarded to me by the Engineer Dept.), a stratum so soft that the augur sank in it by its own weight, was met with at 58 ft., after striking, at 56 ft. a stream of water which "filled the pipe."

If then, the mud stratum, lying, say 60 ft., below the surface, be pressed by a column of deposit of 1·75 sp. gr., mud of sp. gr. 1·25 could thereby be raised 24 feet above the top of the pressing column; and this, considering the average depth of water on the bar, would account for the greatest heights to which cones are built up off the mouths.

But this is a close calculation, even if the data upon which it is based be deemed admissible in the form I have given them; and the frequency and energy with which the upheaving force acts, coupled with the fact that when a mudlump rises in the channel, so far from suffering denudation to the extent required for the breaking through of the mud, it more generally causes a silting up of the channel: seems to me to indicate that

* Humphreys and Abbot's Rept., p. 446.

a stronger force, less delicately balanced than the equilibrium of the bar, is "at the bottom" of the whole phenomenon.

This force, I think, is to be sought in the constantly increasing weight of the alluvial area above the mouths, which, itself possessing a series of mudlump vents at one time, must yet be resting in a great measure upon the still unexhausted mud stratum; as is proven by the existence of active lumps in the marshes, even though the increased resistance of superincumbent deposit as well as matted vegetation must render their occurrence there a rarity. There must still be a communication of liquid pressure between the older and newer portions of the modern delta; and this point is especially strengthened by the fact that a high stage of water in the river, which does not sensibly affect the depth on the bars, yet exerts a decided influence on mudlump activity. The river not only overflows the marshes, but loads them with additional sediment; and doubtless the increased hydrostatic pressure stops many a vent of gas, mud or water, which ordinarily discharges into the river's bed.*

Morgan's Lump, in the marsh of Southwest Pass, and Marindin's Lump on Passe à l'Outre, are now known to have been in undiminished activity for twenty-five years at least. Since that time the bars have moved gulfward a mile and a half; and one would think that, if the activity of the cones depended upon them alone, a notable difference ought to have been observed. But if the main force is a *vis à tergo*, while the bar serves mainly to prevent the escape of the mud to seaward, there is good cause for the secular persistence of vents that have escaped mechanical obstruction.

How far above the present mouths the head of pressure may extend, I do not pretend to conjecture. The borings at New Orleans seem to indicate that the mud stratum originally existed there also, but it would be extravagant to suppose that such pressure as that exerted in the gas wells of that city, could now be felt a hundred miles below. Yet it seems not at all unlikely, that the weight which steadily forces up the liquid mud to the top of Morgan's Lump, seven miles above the mouth, may, in part, be furnished by the enormous mass of vegetation which annually develops in the marshes, willow battures, and perhaps even cypress swamps above. Nor is the effect of gaseous pressure resulting from the constantly progressing decay of organic matter to be overlooked, although I doubt that this cause plays, ordinarily, anything more than a very subordinate part.

* I give on the plate (page 358) an ideal section, illustrating this explanation of the "origin of mudlumps."

Future observations, systematically carried out, will doubtless solve a good many of the questions here mooted; and though they may not lead to the suggestion of any means whereby the "evil geniuses of the Passes" may at present be conjured, a more precise knowledge of data, as well as of the statics and dynamics of *mud*, may enable us to predict at what point of advance of the mouths into the deeper water of the Gulf, their formation must cease. The Southwest Pass appears to be nearest that consummation devoutly to be wished; and were the closing of the other outlets practicable, the advance of the Southwest bar might become so rapid, as to let the youngest of the living generation witness a diminution of mudlump upheaval. Ultimately, the mouth might thus become similar to those of the Orinoco and Amazon; but until then, ceaseless activity of the river in the formation of bars and mudlumps must, in the interest of navigation and commerce, be met by an equally ceaseless and diligent effort for their removal from the channel. For while a concentration of the river current might possibly be made to maintain the needful depth upon the bars, its utmost erosive energy will be powerless against the tough, inert masses of the mudlumps.

ART. LXIII.—*Observations on the Structure and habitat of the Stephanurus dentatus* Diesing, *or Sclerostoma pinguicola* Verrill; by WM. B. FLETCHER, M.D.

THIS parasite, well known throughout the west as the "kidney worm," was first discovered, as I am informed, by Nattser, at Barra De Rio Negro in the white China hog. Although so common and injurious in this country, it had not received attention until 1870, when Prof. Verrill, from imperfect specimens, gave it a name and suggested its importance to the agricultural world.*

* Subsequent to the publication of my descriptions of this species in the Report of the Connecticut Board of Agriculture for 1870, and this Journal, vol. l, p. 223, I found a notice, apparently of the same worm, by Dr. J. C. White, in the Proceedings of the Boston Society of Natural History, vol. vi, p. 428, Dec., 1858. Dr. White referred it doubtfully to *Stephanurus dentatus* Dies. or *Sclerostomum dentatum* Rud. (an identification that is still quite doubtful) and gave an account of its occurrence in cysts in the leaf-lard of a hog, a male and female together.

Dr. Cobbold, from information received through Dr. Fletcher, has recently published a short account of this parasite, under the same name, in the British Medical Journal (see also Nature, Jan. 26, 1871).

During the past winter I have known of several additional cases in New England. In one instance I obtained a number of fine specimens from a portion of the leaf-lard, taken from a hog raised in Litchfield county, in this state. They occupied large irregular cavities or cysts, sometimes over an inch long and partially filled with dark, disagreeable pus, in which there were numerous eggs. The cysts usually contained a male and female worm, but some contained three and others only one.—A. E. V.

This worm was brought to me in 1866, by a farmer whose hogs were dying of cholera. He had removed the lungs of several, and also cut out fragments of the liver, all of which were spotted over with little cysts containing the worms; in the bronchial tubes down to the minutest branches, they were found in abundance and in situations where no one could have placed them.

With these specimens my conclusion was that they were the *Filaria bronchialis* of Owen, or *Strongylus bronchialis* of Cobbold, and not having at this time made microscopic examination of our well known kidney-worm, the relationship between them did not occur to me at that time.

In November, 1870, while demonstrating the portal circulation in the liver of a pig, full grown, I observed a worm which measured an inch and a half in length, and in all respects resembled the kidney worm, and also reminded me of the worms I had examined five years before. Upon further dissection of the liver I found the worms not only free in the portal veins, but in cysts in various portions of the organ; also some were found in freshly cut holes, directly across the hepatic lobules. The gall-bladder was distended with a dirty, yellowish fluid, the consistency of soft boiled eggs, and although no worms were found, yet the ova were abundant, as they also were in the fluid of the cysts.

Being convinced that the worm formerly examined in the lungs was the same as the worm now found in this new locality, and finding it oviparous, I gave up my opinion as to its being a *Filaria bronchialis*.

From the date of this discovery, I frequented the slaughter houses and pork-packing establishments, and found the worm in most instances in the pelvis of the kidney, or in cysts in the fat around them. Four times I have found the worm in the bronchial tubes, twice in the hepatic vein and in the right side of the heart; also in cysts throughout the fatty parts of the animal.

Frequently, when no worms were discovered, the eggs were abundant in the thick mucous-looking fluid in the pelvis of the kidney. This fluid contained, besides eggs, desquamated renal tubules, or casts and oily granules.

In no instance have I found worms in an immature state, which shows that the eggs, in all probability, go through some other beast before they enter the swine, to become sexually mature.*

The symptoms in hogs, which are referred to the "kidney worm," are due to a paralysis of motion in the hind legs; the

* It is quite as probable that they may hatch in water, and thus enter the hog's stomach with its drink.—V.

hog drags the hind quarters along the ground from place to place in search of his food, although it is by no means proven that the worm is the real cause, unless we be able to demonstrate its existence in some cerebro-spinal center, or some point more likely to destroy the reflex power in the cord itself.

Structure.—The head and oral cavity are alike in male and female. The oral cavity is rather oval than round, and is surrounded by a hexagonal frame, each corner having a papilla and hooklet, while each side is armed with six serrate teeth.

Looking into the oral cavity, it is funnel-shaped, having three openings at the back, one of which connects directly with the œsophagus, while the others appear to connect with the water vessels.

The intestine is long and contains some pigment granules, arranged in dendritic forms, throughout its length; the whole is thrown into convolutions, and gives an almost black appearance to the worm, except when the white oviducts distended with eggs, or the seminial vessels of the male are folded over the intestine, when it has a white, mottled appearance.

The caudal extremity of the female is spindle-shaped, but has two little bursæ higher up. In the male it is formed by three-lobed bursæ, above which are two well developed flexible spi ula.

Art. LXIV.—*On certain Forms of the Electrical Discharge in Air;* by Prof. Arthur W. Wright, Williams College.

In a paper published in this Journal, May, 1870, the writer described a peculiar form of discharge between the poles of the Holtz electrical machine, worked at high tension, and without condensers. A non-luminous discharge was observed to take place over a considerable interval, with the production of a jet or brush upon the negative, and a glow upon the positive ball, and the formation in this glow of shadow-like images of objects placed between the poles. It was shown also that the discharge passed over lines having a definite form, and that they were curved so as to form arcs issuing normally from the surfaces of the poles.*

When the condensers are employed the dark discharge also occurs under certain circumstances, and exercises an important

* Faraday described the form of discharge which produces the glow, and called it the *dark discharge*. He also held that the inductive action between two bodies took place along curved lines, as was indicated by certain forms of the luminous discharge. (Exper. Res., 1444; 1544, et seq.; 1215, et seq.). The occurrence of the shadows, however, enables us to trace these lines of action very accurately, especially when the glow is made to take the form of a narrow ring, as is described in the paper referred to above.

influence on the nature of the phenomena observed. If the poles of the machine are gradually separated, a point is soon reached, at which the bright sparks appear very irregularly or cease altogether, the polar interval being then usually some four or five inches, but varying considerably with the circumstances of the experiment. Examination readily shows that at such times a dark discharge is taking place, and shadows may be produced in the same manner as when the condensers are not used, but less readily, and with less distinctness. The discharge now becomes very variable in character, passing from the ordinary bright spark to the non-luminous form already described, and all intermediate grades may be observed, according to the energy of the jet, or the tension of the poles.

Often an incomplete spark passes, consisting of two portions issuing simultaneously from the poles, the middle portion being quite dark. The two ends, in this case, are usually characterized by many branches, which are more numerous and longer in the part next the positive pole, and the whole exhibits a reddish color, and a feeble degree of illuminating power, as compared with the perfect spark, while the detonation of the discharge is correspondingly enfeebled. This is the case distinguished by Riess as the "weak spark" (*schwache Funke*),* and it is characterized by him as a distinct form of the discharge, due to a diminution of the tension of the electricity.

That under particular circumstances, or with a special arrangement of the machine, such as to give electricity of lower tension, the weak sparks are produced more frequently, is true, but the fact that they are often formed when the potential of the machine is very high, shows that they are not dependent on that alone, but rather upon the tension at the poles, at the instant of discharge. In these cases, the poles being separated but a few inches, a rapid jet-discharge takes place, with the production of the phosphorescent glow above described. Now when this occurs, a silent discharge is going on through the air, and this may be so energetic as completely to prevent the formation of the ordinary spark, and to lower the tension at the poles very considerably. A variation in the rapidity with which the machine is worked, or the prevention or weakening of the jet by any means, may then raise the tension of the poles sufficiently to determine the passage of the weak sparks, or even of the ordinary bright ones.

It may be supposed that, at the distance in question, the mutual inductive influence of the two poles is just sufficient to cause a local increase of tension there, to such a degree as to enable the negative electricity to overcome the resistance of the air, thus setting up a sort of current between the poles. And

* Pogg. Ann., Bd. cxxxvii, p. 451; Bd. cxxxix, p. 508.

it is noticeable that after such a current is once established the poles may often be gradually separated to a much greater distance without interrupting it, though if, after this greater separation, the spark passes, or the poles are touched with a conductor, the current is not readily re-established without approaching them to each other again. The analogy of this circumstance, as well as of the curved form of the lines which the current often exhibits, with similar phenomena of the voltaic arc, is obvious.

Riess has remarked (loc. cit.) that the weak spark may be regarded as the germ of the complete and bright sparks. We may go further, however, and say that the brush-discharge is the germ of both the others, and indeed of most of the luminous forms of discharge. When an elongated conductor, connected with the machine and highly charged, is insulated, and so far removed from any other conducting body that the attractive influence of the latter is null, or may regarded as such, the tension quickly rises to a maximum at the extremities, and, if these terminate in blunt points or small balls, finally overcomes the atmospheric resistance, and a discharge occurs in the form of a brush, or rather in that of a tree, the stem of which is toward the charged body. The ramified form of the discharge is evidently due both to the tension of the electricity, and to the small electrical capacity of the air. The portion of the air in contact with the pole becomes highly charged and is then repelled, and a stream of such particles will follow in rapid succession. Each of these particles communicates a portion of its charge to others which it touches, and so is in a condition to receive more electricity from the charged body. Thus is established, not merely a convective action in the particles of air, but also a current of electricity passing along the stream of particles. The stream or thread of air is heated by the passage of the electricity, and all the more as its resistance is very great. With the rise in the temperature, however, its conducting power is increased, and it thus not only conveys a larger quantity of electricity, but becomes more highly charged, until finally, acting itself as a highly charged body, it gives rise to other streams forming branches or lateral discharges, which in turn give rise to other ramifications, thus producing the familiar arborescent forms of the discharge.

When two conductors oppositely charged with electricity are brought so near one another that inductive action becomes sufficiently intense, we may have either the silent and non-luminous discharge, or if the quantity of electrity is too great to find its equilibrium in this manner, the brush-discharge taking place from both poles simultaneously, and greatly intensified by their mutual action. The branches become longer, more

distinct, and more highly luminous, and when the distance between the poles is so small that the branches are separated by a comparatively small interval, we may have the weak spark. Finally, when the quantity of the electricity is increased, or the tension at the poles becomes greater, or the distance between them is lessened, the branches of the primary discharge may become so much extended as to meet, or at least to come into close proximity. Now it is well known that when a body has been traversed by or charged with electricity either positive or negative, it becomes a better conductor for electricity of the opposite nature. In case then any branch from one side, say the positive, should meet one from the other side, namely, the negative, each would form for the electricity of the other a better path than the surrounding air, both from this cause, and from the fact that it has a higher temperature. The main body of the charge then would follow the path thus opened, and the thread of air which it traverses being thereby very highly heated would exhibit the intense brightness of the ordinary spark. The fact that the discharge passes along the irregular branches of the brush then sufficiently explains the crinkled and variously contorted forms of the bright spark, when the tension is very great. With a machine affording electricity of high tension, the branches accompanying the bright sparks, when the latter have a length of some inches, may be readily seen even in the daylight. The longer and more numerous proceed from toward the positive side, but those directed from the negative are frequently visible. They are much shorter and less distinct than the former. Sometimes short and faint branches issue from different points of the negative pole itself, several appearing at once, simultaneously with the spark.

From the fact that the air in the path of the spark is rendered a better conductor by the intense heat, it might be expected that where a rapid succession of discharges passes, the successive sparks would follow the same path, and therefore have the same form, as the air-thread would not instantly communicate its heat to the air surrounding it. The researches of Feddersen and of Prof. Rood have shown that in the discharge of the Leyden jar through a short interval, the spark is intermittent in its character, consisting in fact of several discharges in rapid succession. As the bright path appears to the eye single and sharply defined, it is very probable that their paths are all identical, namely that of the first act of the discharge. With the Holtz machine also, used without condensers, the discharges may be made so rapid when the poles are but an inch or less apart, as to appear continuous, and to give a tone whose pitch can be definitely recognized. In such a case the lines of the discharge seem to oscillate rapidly in a plane which has differ-

ent inclinations as the thread of air is moved in one direction or another, either by currents in the surrounding air, or, as apparently happens, by the attraction of the charged parts of the machine. When no disturbing cause affects it, the plane will tend to take a vertical position, from the diminished density of the air-thread which is heated by the discharge. In any case, as it moves from its first position, and the repeated discharges pass through it, it occupies positions successively farther from the original line, until from its increased length the resistance becomes too great, and the discharge occurs again near the initial position, and so on. Owing to the persistance of the impression in the eye several lines are seen at once, apparently simultaneous, but that they are not so may be readily made evident by suddenly moving the eye while looking at them, or by viewing them in a mirror which is quickly turned about, when the intervals between them are seen to be drawn out and enlarged, whereas these would be unchanged if the discharges occurred at the same instant, or were continuous.

The effect becomes much more striking when the poles are so shaped as to increase the vertical length of the space between them. For this purpose an experiment was made by attaching to the inner extremity of each electrode a brass tube about six inches in length and half an inch in diameter, the upper end being hemispherical, and the tubes fixed in a vertical position. When the electrodes were pushed in so that the tubes were from one-quarter to one-half of an inch apart, and the latter were brought as nearly as possible to parallelism, sparks passed in quick succession between them, and now and then appeared to rise rapidly from the lower portion of the interval toward the top. When the condensers were employed, and the tubes were brought nearer together, the same effect was observed, but indistinctly and less frequently, as the discharges succeeded one another too slowly to make it readily apparent.

A phenomenon of the same kind is often presented in lightning flashes. It is no uncommon thing during a violent thunder-storm, to see two, three, or even more discharges of lightning follow the same path in quick succession, the interval between them being but the fraction of a second, yet sufficient to be distinctly perceptible. In this case the mass of air heated by the discharge is comparatively great, so that a considerable time is required for it to become cooled by the enveloping air, and it therefore retains its superior conductivity long enough to determine a repetition of the discharge through it.

The formation of the electrical shadow discussed in my former paper, as has been suggested by Mr. C. F. Varley,* who

* *Nature*, vol. iii, p. 238, in report of Proc. Roy. Soc. for Jan. 12, 1871.

has more recently obtained results similar to those there described, appears to afford a satisfactory explanation of a singular and very interesting phenomenon which has occasionally been observed in the case of objects struck by lightning, especially of persons killed by it. A number of instances are on record where the person struck was found to have impressed upon some portion of the body a delineation of some thing near him at the time of the stroke, and a similar effect has been noticed also in the case of inanimate objects. Dr. Franklin mentions an instance in which an exact representation of a tree was imprinted upon the breast of a man who was standing near it when struck by lightning. A number of similar and very remarkable cases are cited in a paper presented to the Royal Society of England, by Mr. Andrés Poey, director of the observatory at Havana.*

Mr. Varley also mentions cases reported by sea-captains, of images of certain brass numbers attached to the rigging of a ship being printed by the lightning upon the body of persons killed by it, and supposes the brass numbers to have acted as a negative pole in respect to the person struck. But it is unnecessary to suppose that the discharge in such cases always proceeds from the object delineated, and many of the instances recorded forbid such a supposition. The experiments in the production of the electrical shadows show that it is merely necessary that the object should interrupt the lines of action of the electricity, and that it may be at a considerable distance from the electrified cloud, the chief and indispensable condition being that the latter should be negatively electrified. We should then have the body exposed to the lightning positively electrified by induction, and, as the tension became sufficient, the dark discharge accompanied by the glow would take place, followed by the lightning-stroke. If then any object should be in the path of the discharge, its image would be formed in the glow, and this might, in rare cases like those recorded, be sufficiently intense to leave a permanently visible impression. The fact that the image in many cases is very much reduced in size, shows indeed that the cloud, or other body serving as the negative pole, is much more distant from the object represented than is the body struck, for in the experiments described in my former paper, it was found that the image of the paper grating grew much smaller as it approached the positive pole, and this effect would be likely to be still more marked where the negative body had a very extended surface, as would be the case were it a cloud.

In some experiments recently made, the negative pole of the machine was covered with several folds of woolen flannel which

* See an abstract of this paper in the Ann. Sci. Discovery, 1858, p. 226.

prevented the formation of a jet. Instead of this, several square inches of the cloth were covered with a bright glow, somewhat resembling that on the positive ball, but, unlike that, seemingly made up of innumerable minute points or patches of light, having a peculiar swarming motion, like that described by Neef in his researches upon the negative discharge as seen under the microscope. When the paper grating was placed between the poles, the image on the positive was not readily obtained with distinctness, but was generally much smaller than when the negative pole was not thus covered.

A similar effect, but much more brilliant, was produced when, the poles being separated nine or ten inches, the hand was placed upon the negative, and the arm was approached to the positive pole. The woolen sleeve exhibited a bright glow covering a large area, and appearing like a strongly phosphorescent powder sifted profusely upon it. When this was approached so near that the interval was only an inch and one half or an inch, the positive glow became much more intense, and took a delicate purplish tinge, and the whole space between the two was filled with a very faint auroral light, which appeared, unlike other forms of the discharge, to be perfectly continuous and steady. The dark discharge under these circumstances was evidently so much intensified as to become luminous and visible.

Williamstown, Mass., April 22, 1871.

ART. LXV.—*Brief Contributions to Zoölogy from the Museum of Yale College.* No. XIV.—*Descriptions of new and imperfectly known Ascidians from New England;* by A. E. VERRILL.

[Continued from page 294.]

Family, DIDEMNIDÆ.

In this family we include, together with the typical genera, *Leptoclinum* and its allies, which have been separated as a distinct family (*Leptoclinidæ*) by Prof. Gill.* There appears to be no definite ground for such a distinction. The genera *Didemnum* and *Leptoclinum* are very closely allied, and scarcely distinguishable so far as the structure of the individual zoöids is concerned, the difference being chiefly in the mode of aggregation. Such differences are generally of too little importance among compound animals to form the basis of family distinctions, unless accompanied by important differences in the individuals themselves.

* Arrangement of the Families of Mollusks, p. 23, 1871.

Lissoclinum, gen. nov.

Allied to *Leptoclinum*. The colonies form more or less broad, thin, encrusting masses or sheets, soft and somewhat gelatinous in texture, without calcareous corpuscles. The zoöids are arranged in more or less irregular, scattered systems, consisting of many individuals placed along cloacal ducts, which are connected with common external orifices. Branchial region, or "thorax," equal to or larger than the abdominal. Branchial orifice with six papillæ. Anal orifice lateral or subterminal, prominent. Abdomen separated from thorax by a short peduncle. Stomach with longitudinal glandular ridges. Ovary sublateral, when filled with eggs projecting backward beyond the abdominal viscera. Eggs large.

This genus differs from *Didemum** and *Eucœlium* in having common cloacal ducts and orifices, as well as in the form and position of the abdomen and ovary. From *Leptoclinum* it differs in the soft gelatinous texture and in the form and structure of the zoöids.

Besides the two following species, this genus appears to include *L. gelatinosum* and *L. Listerianum*, both of which were referred to *Leptoclinum* by Milne Edwards.

Lissoclinum aureum, sp. nov. Figure 26.

Colonies encrusting, forming nearly flat masses, about ·15 to ·20 of an inch thick, and up to an inch or more in diameter. Texture soft and gelatinous, semi-transparent. Systems irregular, consisting of many individuals arranged along the elongated, common cloacal ducts. Branchial orifice with six rather elongated and slender papillæ. Branchial sac broad and laterally extended, with the transverse vessels quite distinct, and the longitudinal ones less so. The œsophagus is short; stomach more or less oval and elongated, with well-marked longitudinal ridges or glands; intestine large, prolonged toward the anal orifice. The anal tube is nearly terminal, conical, and more or less prominent. Ovary lateral, when full of eggs projecting backward beyond the end of the abdomen. Color of the common mass light yellow; zoöids bright orange.

26

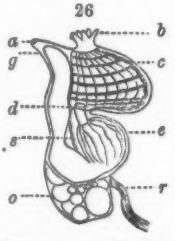


Figure 26, *Lissoclinum aureum* V.—One of the zoöids, enlarged 10 diameters; *a*, anal orifice; *b*, branchial orifice; *c*, branchial sac; *d*, œsophagus; *e*, stomach; *g*, end of intestine; *o*, ovary distended with eggs of various sizes; *r*, "marginal tube" or pedicle of a bud; *s*, spermatic duct. (From a camera-lucida drawing by the author).

* The genus, *Didemum*, as established by Savigny and adopted by Milne Edwards, includes two distinct groups: the first having calcareous corpuscles in its integument; the second soft and gelatinous throughout. The latter may be called *Lioclinum*. It includes *L. viscosum* (Sav.) and *L. gelatinosum* (Edw.).

The zoöids, as preserved in glycerine, are ·10 to ·13 of an inch long; breadth, across branchial sac, ·05 to ·07; across abdomen, ·05 to ·06; length of thorax ·04 to ·07; of peduncle ·005 to ·010; of abdomen ·045 to ·055.

Eastport Harbor, 12 to 20 fathoms,—Expedition of 1870.

The cloacal ducts of a specimen taken in August, were found to be filled with chains of eggs containing the tadpole-shaped embryos in an advanced stage of development. No eggs or embryos were observed in the atrium of the numerous zoöids examined.

Lissoclinum tenerum, sp. nov.

Colonies encrusting shells, ascidians, etc., forming thin, soft, gelatinous crusts, which are translucent, and filled with numerous, very small zoöids, which are nearly uniformly distributed. Cloacal openings small, round, numerously scattered over the surface. Zoöids have the branchial region more elongated and narrower than in the preceding species, with a somewhat larger peduncle between it and the abdomen, and with the latter, exclusive of the distended ovaries, smaller than the branchial region. Stomach elongated, longitudinally ribbed. Branchial tube elongated, with six short papillæ; anal short, broad, lateral, below the middle of the branchial sac, slightly six-lobed.

Color not observed in life; in alcohol transparent whitish, with yellowish white zoöids.

The colonies are up to two inches in diameter and ·10 to ·12 thick; zoöids about ·07 long; the thorax ·032, by ·02 wide; the abdomen ·025 long, by ·015 in diameter, exclusive of the distended ovaries, which in some cases are as large as the entire body.

Eastport, Me., 10 to 40 fathoms, shelly bottom,—Exp. 1870; Banks of Newfoundland,—T. M. Coffin.

This species may be easily distinguished from the preceding by the very small zoöids and paler color. The zoöids are very different in form, owing to the lateral position of the anal orifice. The stomach is remarkably elongated and slender in young individuals, projecting into a posterior prolongation of the abdomen. The eggs are few and relatively very large. Many of them appear to become detached by rupturing the membranes of the ovary, and escaping into the gelatinous common tissue, develop there.

The development of such eggs* is *direct, without passing through a tadpole-shaped larval state.* Scattered through the common gelatinous mass, young ones may be found in all

* With the alcoholic specimens it is not possible to trace completely the early stages of this development, or to be perfectly certain that these egg-like bodies are genuine eggs, although some of them appear to contain, at first, a germinal vesicle.

stages of development. The branchial and anal tubes are widely separated in the young, and the stomach projects backward beyond the body.

Leptoclinum albidum, sp. nov.

Colonies encrusting stones, dead shells, ascidians, etc., forming broad, thin, irregular, coriaceous crusts, with an uneven surface, filled with minute, white, spherical, calcareous grains or corpuscles, which, under the microscope, have the surface covered with projecting points. Surface of the crusts covered with small, irregular, scattered prominences, in which the branchial orifices are situated. Cloacal orifices few and distantly scattered. Systems irregular, the zoöids scattered, but often arranged in rather indistinct concentric circles around the cloacal openings.

Color white, the zoöids light yellowish.

The colonies often become 1 to 2 inches across, sometimes 2 inches or more long, and only ·25 or less wide; thickness seldom more than ·10, commonly about ·05; zoöids ·02 to ·03 long; diameter ·01 to ·012 of an inch.

Eastport, Me., low water on under side of rocks, to 100 fathoms on stony and shelly bottoms, common.—Expeditions of 1863, '64, '68, '70; Grand Menan, 10 to 15 fathoms,—Exp. 1870; Labrador,—A. S. Packard; Mingan Islands, Lab.—A. E. Verrill; Banks of Newfoundland, — T. M. Coffin; Thimble Islands (near New Haven), Conn., 6 fathoms, on rocky bottom,—A. E. Verrill.

Leptoclinum luteolum, sp. nov.

This species forms thin, coriaceous crusts, like the preceding, and filled in the same way with similar spherical corpuscles. The branchial orifices open at the summits of low verrucæ. The cloacal orifices are small, with four to six lobes, and distantly scattered. Color deep salmon, or somewhat rosy.

The crusts are of all sizes up to 2 inches or more in diameter, and are usually somewhat thicker than in the preceding species, with larger and darker colored zoöids.

Eastport, Me., and Grand Menan, with the preceding species,—Expeditions of 1861, '63, '64, '68, '70,

Under the name of "*Didemnium roseum* Sars" Dr. Packard* probably included both this and the preceding species. Mr. Binney, in the second edition of Gould's Invert. of Mass., has merely copied from Dr. Packard's work.

* Memoirs of the Boston Society of Natural History, vol. i, p. 276, 1867.

ART. LXVI.—*Notice of some new Fossil Reptiles from the Cretaceous and Tertiary Formations;* by O. C. MARSH, Professor of Paleontology in Yale College.

THE remains briefly described in the present preliminary notice were collected by the Yale College party during their explorations last summer in the Rocky Mountain region. The specimens from the Cretaceous formation are of great interest, as they further illustrate the remarkable development in this country, both in numbers and distinct forms, of the Mosasauroid Reptiles, which appear to have been comparatively rare in other parts of the world. Fortunately, moreover, some of these remains serve to clear up several obscure points in the structure of these reptiles, and prove conclusively that they had a well developed pelvic arch and posterior limbs; although up to the present time no satisfactory indication of this had been discovered, and the eminent paleontologists who have recently made these animals an especial study consider them probably destitute of these extremities. The remains found in the Tertiary deposits are also of importance, since they show that types of reptilian life, almost unknown hitherto from that formation in the West, were, in one of the ancient lake-basins at least, abundantly represented there during that period.

CRETACEOUS REPTILES.

Edestosaurus dispar*, gen. et sp. nov.

This genus, which so far as now known includes but two species of small Mosasauroids, is especially distinguished from *Clidastes*, its nearest ally, by the insertion of the pterygoid teeth, which are pleurodont in the anterior half of the series, and in the posterior portion have the outer dental margin protected by a low parapet of bone. From *Platecarpus*, the genus is widely separated by the zygosphene articulation of the vertebræ. The pelvic arch and posterior limbs were well developed, but there was apparently no sacrum.

The present species is mainly established on the more important parts of a skeleton, including the greater portion of the skull, both quadrates, about seventy vertebræ, parts of the scapular and pelvic arches, and fragments of the limbs. The remains are in an excellent state of preservation, and indicate a Mosasauroid reptile, apparently about thirty feet in length, or near the size of *Clidastes iguanavus* Cope.

The vertebræ possess the complete zygosphene articulation. In the cervicals and anterior dorsals, the cup and ball are somewhat inclined; in the posterior dorsals and lumbars, less so;

* Εδεστής, devourer, and Σαῦρος, lizard.

and in the anterior caudals they are nearly, but not quite, vertical. The articular faces in the cervicals are a broad transverse oval, faintly emarginated above for the neural canal. In the dorsals and lumbars the cup continues transverse, and the emargination is deeper, but in the anterior caudals the outline becomes a vertical oval. The posterior lumbars have the faces hexagonal, with both the upper and lower borders excavated, the latter due to the concave inferior surface of the centrum in this part of the series. The rim of the articular ball in all the vertebræ preserved is surrounded by a distinct, but not deep, double groove. The chevron bones are coössified with the centrum.

The quadrate has the same general form as in *Clidastes propython*, but the external angle is situated further back, and has a notch in its posterior margin directly above the meatal pit. The postero-superior process is shorter, with a compressed free end. The teeth are curved, and somewhat compressed. The enamel is smooth, and shows faint indications of broad facets on the basal half. There appear to have been thirteen mandibular teeth, with alveolæ for two more. The splenial extends forward to the base of the seventh tooth from the front. The pterygoid bones were separated, except perhaps at their anterior inner margin. There were at least fifteen pterygoid teeth. The crowns are smooth, with distinct posterior cutting edges.

There is a remarkable difference in size between the cervical vertebræ and those of the lumbar region, where the centra reach their maximum. Although the series is here apparently complete, there are no indications of a sacrum. The discovery of the nearly entire pelvic arch with these vertebræ, and the preservation, also, of the corresponding anterior arch, throws much new light on the nature of the limbs in this group of reptiles. These specimens clearly indicate that the bones forming this portion of the skeleton in the Mosasauroids have not unfrequently been incorrectly assigned, and that two at least of the allied genera, viz: *Clidastes* and *Liodon*, also possessed effective posterior limbs. Several series of specimens illustrating this are in the Museum of Yale College, and will soon be described by the writer.

In this species the scapula and coracoid bones are similar to those of *Mosasaurus*. Both are short and flat; each thickened at one extremity, which it contributes to form the glenoid cavity, and at the other, thin and expanded. The coracoid is perforated by a foramen not far from its anterior margin. The pelvic arch resembles that of *Ichthyosaurus*, and, as in that genus, is considerably smaller than the anterior arch. The acetabulum is cup-shaped, and is not unlike that in *Trionyx*. It is formed by the union of the ilium, pubis, and ischium, the first fur-

nishing the largest, and the last the smallest portion of the articular surface. The body of the ilium is remarkably slender, and the proximal end was probably attached to a vertebra merely by cartilage. The distal extremity is much expanded, subrhombic in outline, and has three nearly equal facets on its articular surface, that forming part of the acetabulum being the largest. The adjoining proximal end of the pubis is more compressed than that of the ilium, and has three corresponding articular facets, the acetabular being nearly flat, and the others concave. The portion below is flattened, and has a foramen near its anterior margin. The proximal end of the ischium is also trihedral, and somewhat smaller than that of the pubis. The articular surfaces of all these bones were thickly capped with cartilage. The few phalanges found with these remains are rod-like, depressed, and much constricted medially. The ends are transverse, and have been covered with cartilage. They indicate that the limbs were paddles, not unlike those of *Plesiosaurus*, but more slender.

Measurements.

Length of axis,	26·	lines.
Length of axis, with odontoid process,	32·	"
Width between diapophyses,	26·8	"
Width of articular ball,	11·25	"
Depth of articular ball,	9·25	"
Length from edge of cup to end of ball in eleventh vertebra,	25·	"
Width of ball,	14·	"
Depth of ball,	12·	"
Length of first caudal on inferior surface,	16·	"
Width of articular cup,	14·5	"
Depth of cup,	15·	"
Length of quadrate,	30·75	"
Transverse extent of distal end,	18·75	"
Length of pterygoid bearing the five anterior teeth,	33·5	"
Length of portion with the five posterior teeth,	23·	"
Antero-posterior diameter of distal end of ilium,	14·5	"
Transverse diameter,	11·30	"
Diameter of shaft,	4·75	"
Greatest diameter of proximal end of pubis,	16·30	"
Transverse diameter,	10·	"
Greatest diameter of proximal end of ischium,	14·	"
Transverse diameter,	9·	"

This species is readily distinguished from *Clidastes iguanavus*, by the less depressed and more constricted centrum in the anterior dorsals. It differs essentially also from *Clidastes cineriarum* Cope, in having transverse articular faces in the vertebræ of the dorsal and lumbar region. The specimens representing this species were discovered, in November last, by Mr. H. B. Sargent

and the writer, in the gray Cretaceous shale, on the North Fork of the Smoky River, in Kansas.

Edestosaurus velox, sp. nov.

This species was about two thirds the size of the preceding one, and very nearly allied to it. It is represented at present by a number of specimens found together, including the greater part of the skull, with the quadrates, and several vertebræ, which, however, are too much crushed to give reliable measurements. Another series of specimens, consisting mainly of anterior dorsal vertebræ, well preserved, was found near the same locality and appears specifically identical. They are therefore included in the description of the species, and furnish the vertebral characters of the dorsal region, where the first series is deficient.

The muzzle in this species is obtusely pointed. The premaxillary is narrow and simple, and unites with the maxillaries, anteriorly at least, by suture, differing in this respect from the known species of *Clidastes*. There are four premaxillary teeth, smooth and subcompressed, like those of the maxillaries. The pterygoid bones are very similar to those of the preceding species. The quadrate, also, has the same general form, but presents several marked differences. The great ala is less curved vertically, and is concave transversely on both surfaces. The alar process has its articular surface very narrow in its extension over the great ala, while in *E. dispar*, it is broad and abruptly terminated. There is no notch in the posterior margin of the external angle. On the ridge below this angle, and nearly opposite the meatal pit, there is a prominent rugosity, which is rudimentary or wanting in the larger species. In the latter, moreover, the posterior margin of the hook is reflected for some distance, producing a broad articular face. In the present species, this surface is only represented by a narrow tongue, projecting toward the meatal pit.

In the cervical and dorsal vertebræ, the articular faces are transverse, and in the latter, distinctly cordate, the superior emargination being deeper than in the preceding species. In the anterior dorsal region, the vertebræ have a more transverse cup and ball, which are also apparently more inclined from a vertical.

Measurements.

Length of anterior dorsal vertebra, from edge of cup to end of ball,	22·	lines.
Width of ball,	12·	"
Depth of ball,	10·	"
Length of pterygoid bearing five anterior teeth,	25·5	"
Length of pterygoid with five posterior teeth,	19·	"
Length of quadrate,	27·75	"
Transverse diameter of lower end,	14·	"

This species was apparently about the size of *Clidastes intermedius* Leidy, but may easily be distinguished from it by its smooth teeth, and the more nearly vertical articular faces of the vertebræ. The present specimens were found by the writer, in the gray shale, near the North Fork of the Smoky River, in Western Kansas.

Clidastes Wymani, sp. nov.

The remains on which this species is based consist of a series of cervical and anterior dorsal vertebræ, with portions of the skull and quadrates of the same individual, and portions of another skeleton, including a nearly or quite complete vertebral series from the posterior lumbars to the extremity of the tail. The two suites of specimens correspond so closely in size and proportions, as well as in special characters, that they may with comparative safety be referred to the same species.

The specimens indicate a small reptile, very near *Clidastes propython* in size, but differing from that species in several important particulars. One of the most noticeable of these is the form of the muzzle, which in the present example has a short and obtuse extremity, not unlike that of *Liodon proriger* Cope. The basioccipital has the condyle deep vertically, and only a shallow groove on its upper surface for the neural canal. The quadrate has the postero-superior process free at its lower extremity. Just below this, there is a prominent rugose knob, with a deep pit under it, entering from the external border.

In the cervical vertebræ, the outline of the articular faces is transverse cordate, the ball of the axis showing a marked difference in this respect from that of *Clidastes propython*, where it is subpentagonal. The centra of the anterior dorsals are elongate, and much constricted behind the diapophyses. The cup here becomes broader, and the emargination deeper. In the anterior caudals, the articular faces are a broad vertical oval. The vertebræ in this region have deeply concave sides. In the twenty-fifth caudal, or vertebra with chevrons where the last rudiment of the diapophysis has disappeared, the transverse and vertical diameter of the cup, and the length of the centrum are very nearly equal. In the median caudals, the centra become compressed, the cup is very shallow, and the neural spines and chevrons are directed backward. The posterior caudals are much compressed, with the cup very deep, the neural spine still inclined, but the chevrons are nearly perpendicular. The entire caudal series, excepting those at the very extremity, have coössified chevron bones. There are eighty-one caudal vertebræ preserved, the last fifty being continuous. The terminal ones are less than one-twelfth of an inch in transverse diameter! This series would imply that there were considerably more than

two hundred vetebræ in the entire column, and hence indicates for these reptiles a much more attenuated, serpent-like form than has hitherto been supposed. The present species was probably about eighteen feet in length.

Measurements.

Length of axis, with odontoid process,	19·	lines.
Width between diapophyses,	17·	"
Width of ball,	8·	"
Depth of ball,	7·	"
Depth of centrum, with attached hypapophysis,	10·3	"
Length of sixth cervical, without ball,	13·	"
Length of neural arch,	10·	"
Width in narrowest point,	6·40	"
Width of cup,	9·	"
Distance from end of muzzle to center of first tooth,	5·5	"
Length of caudal on which diapophyses first disappear,	9·1	"
Width of cup,	9·	"
Depth of cup,	9·	"
Length of caudal, apparently next to last,	1·40	"
Transverse diameter of same,	·95	"

This species is named in honor of Professor Jeffries Wyman, of Harvard University. The remains at present representing it are from the gray Cretaceous shale of Western Kansas. The first series of specimens here described was discovered by Mr. H. B. Sargent, on the North Fork of the Smoky River. The caudal series was found by the writer, about ten miles further east, near the Smoky River.

Clidastes pumilus, sp. nov.

The smallest Mosasauroid reptile at present known is indicated by the anterior portion of a skeleton, which appears to be specifically distinct from any hitherto described, although seemingly most nearly related to the species characterized in the preceding description. Aside from the more diminutive size, however, there are several noticeable differences. In the present species, the inner third of the distal articular surface of the quadrate is much broader, and less separated by constriction from the main condylar surface. The cotylus of the articular bone, also, has a corresponding greater width. The rugose knob near the distal end of the quadrate is similar to that in the last species, but has no pit beneath it. The hook is comparatively short, and has a free compressed extremity. Its articular margin is not deflected toward the meatus. The basioccipital is longer, deeply excavated for the neural canal, and its condyle is much less elevated. The teeth are nearly round at the base, somewhat curved, and with smooth enamel. The articular faces of the cervical vertebræ are nearly vertical, and

have a broad transverse oval outline, with a faint superior emargination. The free hypapophyses preserved are short, and triangular transversely.

Measurements.

Length of axis, without odontoid process,	12·3 lines.
Width of ball,	7·10 "
Depth of ball,	5·75 "
Transverse extent of distal end of quadrate,	10· "
Length of basioccipital,	13·45 "

This species was probably about twelve feet in length. The specimens representing it, so far as now known, were found by Mr. H. B. Sargent, of the Yale College party, in the yellow Cretaceous limestone, on the south side of the Smoky River, Western Kansas.

Tertiary Reptiles.

Crocodilus ziphodon, sp. nov.

Some of the most interesting remains of fossil reptiles discovered by the Yale party, during their explorations last summer in the Tertiary beds of the Green River basin, west of the Rocky Mountains, were those of Crocodilians, several of which prove on examination to be new to science. One of these, a small animal to which the present name may be applied, presents characters which separate it at once from any known Crocodilian, living or extinct. Perhaps the most marked feature is seen in the teeth, which resemble those of some of the Dinosaurs. The crowns are much compressed, and somewhat curved, especially in those apparently pertaining to the front part of the series. The sides are smooth, the edges very sharp, and marked with fine serrations from the base to the apex. The skull was rugose, and in places deeply pitted. The quadrate, to judge from a single detached specimen found with one series of the remains, and probably belonging to them, is quite stout, with the lower surface smooth, and the distal end subtriangular in outline. The back of this reptile was covered with thick scutes, closely united by suture, and marked with numerous deep pits.

Measurements.

Length of crown of tooth,	8· lines.
Transverse diameter at base,	2·60 "
Antero-posterior diameter at base,	4·75 "
Transverse diameter of distal end of quadrate,	15·80 "
Vertical diameter, on median line,	7·90 "

The specimens here described were found by Mr. H. B. Sargent, Mr. J. R. Nicholson, and the writer, at the Grizzly Buttes, near Fort Bridger, Wyoming. The geological horizon is upper Eocene, or perhaps Miocene.*

* This Journal, vol. i, March, 1871, p. 192, and May, 1871, p. 322.

Crocodilus liodon, sp. nov.

A second small species of Crocodile is indicated by the more important parts of a skeleton from the same Tertiary deposits as the preceding species. In this specimen the teeth are smooth, nearly round at the base, slender, with compressed points. The cutting edges are prominent and sharp, but not serrated. The jaws are quite slender. The quadrate is short, concave on its upper surface, and very flat at its distal end. The usual pneumatic foramen on the inner superior margin is, in this specimen, wanting or rudimentary. On the lower surface there is a broad longitudinal elevation, which is mainly outside the median line. The basioccipital is stout, and uniformly convex transversely. The axis is elongated, and rather slender. The hypapophyses of the cervicals are simple, compressed, and elongated. In the anterior cervicals they are directed forward, but in the eleventh vertebra, this process is perpendicular. The articular cup is here a very broad transverse oval. The dorsal scutes were articulated.

Measurements.

Transverse diameter of quadrate, at distal end,	14·	lines.
Vertical diameter, on median line,	3·90	"
Length of axis, with odontoid process,	22·25	"
Length of eleventh vertebra, from edge of cup to end of ball,	16·	"
Width of cup,	9·	"
Depth of cup,	8·10	"
Length of hypapophysis,	5·	"

This specimen was nearly, but not quite, adult. It was discovered by Mr. C. T. Ballard, of the Yale party, at Grizzly Buttes, near Fort Bridger.

Crocodilus affinis, sp. nov.

The most common fossil Crocodiles in the Tertiary beds of Western Wyoming are large reptiles, having stout conical rugose teeth, with prominent, but rather obtuse cutting edges, not unlike the teeth of the modern North American Alligator. Professor Leidy has recently described, under the name of *Crocodilus Elliotti*,* a species with these characteristics, which was found in the eastern part of the same Tertiary lake-basin; but a comparison of his original specimens, which he has kindly loaned the writer for this purpose, with the extensive material obtained by the Yale party near Fort Bridger, show clearly that there are two distinct species, about the same size, and with teeth almost identical. The two may be distinguished, how-

* Proceedings Acad. Natural Sciences, Phil., 1870, pp. 100 and 122.

ever, by the premaxillaries, which in the skull described by Professor Leidy are elongate, and have, to the entire length of the skull, a ratio of about one to three. In the second species, to which the name preceding this description may be given, the corresponding parts have the approximate ratio of one to four, as shown by a very perfect skull in the Yale Museum, as well as by other remains which give all the essential characters. The symphysis in this species is quite short, and, at the posterior upper margin, is met by the anterior extremity of the splenial. The nasal bones project forward, and form a septum in the external nostril, as in the Alligator. The cervical vertebræ, moreover, have hypapophyses resembling those in that genus. The quadrate is much constricted at its distal articular end. Its lower surface is concave, with a sharp longitudinal ridge, exterior to the median line.

Measurements.

Length of skull, on upper surface,	13 inches,	9·	lines.
Length of premaxillaries,	3 "	6·	"
Transverse diameter of quadrate, at distal end,		22·50	"
Vertical diameter, on median line,		7·	"

The precise relations of this species to *C. aptus* Leidy, which was described from a single cervical vertebra, cannot at present be decided.

The known specimens of the present species were collected by Mr. H. D. Ziegler, Mr. A. H. Ewing, Mr. E. Whitney, and the writer, at Grizzly Buttes, Wyoming.

Crocodilus Grinnelli, sp. nov.

This species, which was of medium size, closely resembles the preceding in the form and proportions of the quadrate, but differs from it in the more slender jaws, and the more compressed, pointed, and grooved teeth. The symphysis is also longer, and the splenial does not reach it. The basioccipital is transverse, slender and elongate, with a deep vertical groove on the median line. The axis is quite slender, and has two deep, elongated pits, side by side on the floor of the neural canal, and two, less deep and more separated, on the superior surface of the odontoid process. All the vertebræ are strongly striated on the margins of the articular faces. The scutes are free, and with few pits. The specimen here described appears not to have been fully adult, although nearly so.

Measurements.

Length of symphysis,	2 inches,	8·5	lines.
Greatest depth,		9·25	"
Transverse diameter of quadrate, at distal end,		16·75	"
Vertical diameter, on median line,		4·80	"
Length of axis, with odontoid process,		21·75	"

This species is named for the discoverer, Mr. G. B. Grinnell, of the Yale party, who found a nearly perfect skeleton on Marsh's Fork, in Wyoming. The geological horizon is essentially the same as in the three preceding species.

Crocodilus brevicollis, sp. nov.

A number of cervical and dorsal vertebræ, found together, and evidently belonging to the same individual, differ so much from any known Crocodilian remains that they may be considered specifically distinct. Among the most noticeable characters exhibited, are the relative shortness of the atlas and its attached odontoid process; and the presence, on or near the median line of the lower surface in all the vertebræ preserved, of a deep elongated pit, which has a tendency in its forward extension to produce bifid hypapophyses. The eleventh vertebra has the process thus divided. Its diapophyses are also much elongated, and entirely above the line of the neural arch suture. The articular faces are here broadly oval.

Measurements.

Length of axis, with odontoid process,	20·5 lines.
Depth of odontoid process,	9·40 "
Length of process,	6·30 "
Length of eleventh vertebra, from edge of cup to end of ball,	16· "
Greatest distance between diapophyses,	21· "

These specimens were found by Mr. A. H. Ewing, in the Tertiary beds, at Grizzly Buttes, Wyoming.

Glyptosaurus sylvestris, gen. et sp. nov.

Among the most interesting Reptilian remains discovered by the Yale party in the fresh water Tertiary deposits of western Wyoming, were several species of Lacertidæ, or land lizards, of which no fossil representative had at that time been found in this country, although more recently one species has been described by Professor Leidy from the same formation. These remains were found associated with the crocodiles and serpents, already described,* and, together with them, strikingly illustrate the remarkable development of reptilian life during the Tertiary period in one of the great tropical lakes of the Rocky Mountain region.

The specimens discovered evidently represent a peculiar genus of lizards, quite different from any known recent or fossil forms, but in the present preliminary notice only the most marked characters are given, the more exact determination and affinities of the group being reserved for the full description. The head in this genus, for which the name *Glyptosaurus*† is proposed, was

* This Journal, vol. i, May. 1871, p. 322.

† Γλυπτὸς, *embossed*, and Σαῦρος, *lizard*.

covered with large osseous shields, symmetrically arranged, and highly ornamented, resembling in this respect the modern *Heloderma*. Other parts of the body, especially the ventral region, were protected by rectangular, ornamented shields, united to each other by suture, and, in some of the species, these were carinate. The teeth are pleurodont, and, in the species in which they are preserved, are round, with obtuse summits, not unlike those of *Trachydosaurus rugosus* Gray, from Australia. The frontals show, especially in front, a distinct median suture, which forms a slightly obtuse angle with their posterior margin. The articular bone projects behind the cotylus far backward and downward, resembling in this respect the corresponding part in *Varanus Niloticus*. The dorsal and caudal vertebræ have the same general form as those of *Varanus*, but show traces of a zygosphene articulation, especially in their rudimentary zygantral cavities. The tail was long, and apparently rounded. Some of the species were larger than any existing American lizards.

The known species of the present genus may be distinguished from *Saniva ensidens* Leidy,* by the teeth, which in the latter are compressed, pointed, and have sharp cutting edges. There is, moreover, no evidence that this lizard had osseous dermal shields.

The position, form, and ornamentation of the cranial shields will perhaps afford the most convenient and satisfactory characters for distinguishing the species represented in the present collection of lacertian remains, which, although numerous, are more or less fragmentary. The present species may therefore be characterized as having, on the frontals between the orbits, shields of moderate thickness, but little elevated, with those in the middle row on each frontal broader than long. Each shield is covered with numerous small polished tubercles, crowded together with no definite arrangement. Ventral shields with the same ornamentation were found with some remains of this species, and probably belong with them.

Measurements.

Width of single frontal, at posterior margin,	7·80	lines.
Width of single frontal, between orbits,	5·30	"
Length of five posterior shields on middle row of frontal,	9·	"
Length of fragment of jaw bearing three teeth,	4·10	"
Length of ventral shield, probably of this species,	8·40	"
Width of the same,	4·75	"

The present specimens indicate a reptile about four feet in length. They were discovered by Mr. C. T. Ballard and the writer, at Grizzly Buttes, near Fort Bridger, Wyoming, in the same beds that contained the Crocodilian remains.

* Proceedings Philadelphia Acad. Nat. Sciences, 1870, p. 124.

Glyptosaurus nodosus, sp. nov.

In this species, which was somewhat smaller than the one above described, the frontals are thicker at the median suture, and the shields between the orbits very convex. The middle row of each frontal in this region has the shields longer than wide, and subhexagonal. The tubercles on the shields are also proportionally larger, and less crowded together. The plates of the body have the same ornamentation as the cranial shields, and some of them are keeled. The species was about three feet in length.

Measurements.

Width of single frontal, between orbits,	4·50 lines.
Length of four shields on middle row of frontal,	8·60 "
Length of ventral shield,	7·10 "
Width,	3·40 "
Length of dorsal vertebra, from edge of cup to end of ball,	5·60 "
Width of cup,	3·75 "
Depth of cup,	1·95 "
Expansion of posterior zygapophyses,	5·60 "

The specimens representing this species were discovered by the writer, in the fresh-water Tertiary strata, at Grizzly Buttes, Wyoming.

Glyptosaurus ocellatus, sp. nov.

The present species, which was perhaps the largest of the lizards collected by our party, is readily distinguished from the two preceding, by the pattern of ornamentation on the cranial plates, which are very thick, united by suture, and have the tubercles arranged in concentric series. The outer row of tubercles is considerably the largest, and the next two or three successively smaller; while the center is occupied by a group of very small tubercles, with no definite arrangement. The effect of this is to produce an ocellated appearance in each shield, which has suggested the specific name. This effect is increased in one very perfect specimen by the central group of tubercles being of a lighter color.

The only specimens that can at present be referred with certainty to this species were discovered by Mr. H. B. Sargent, in the Tertiary beds at Grizzly Buttes, near Fort Bridger.

Glyptosaurus anceps, sp. nov.

A small species of lizard, quite distinct from those described above, is indicated by numerous fragmentary remains found associated with them in the same deposits. Some of the characters exhibited by these specimens point toward a different genus, but until additional material is obtained, the species may appropriately be placed in *Glyptosaurus*. The vertebræ

have the cup and ball equally transverse with those of the species already described, but they are much less inclined from a vertical. The neural arch is also less elevated in the specimens preserved, and the whole vertebra is more depressed. The teeth are pleurodont. The species was about two feet in length.

Measurements.

Length of posterior dorsal vertebra, from edge of cup to end of ball,	2·80 lines.
Width of cup,	2· "
Depth of cup,	1· "
Expansion of anterior zygapophyses,	4·30 "

The remains on which the present description is based were collected by Mr. C. T. Ballard and the writer, in the Tertiary beds, at Grizzly Buttes, Wyoming. They are now in the Peabody Museum of Yale College, as are all the other specimens described in the present article.

Yale College, New Haven, May 5th, 1871.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On a new series of ammonia-platinum bases.*—P. T. Cleve, to whom we owe an elaborate and valuable investigation of the compounds of platinum with ammonia, has discovered a new and remarkable series in which two atoms of tetratomic platinum combine to form the hexatomic diplatinum. These compounds are formed by treating the iodide, iodonitrate and bromonitrate of Gros's base with ammonia, so that we have the formulas $Pt_2a_8I_4\Theta$,* $Pt_2a_8I_2\Theta_3 2N\Theta_2$, and $Pt_2a_6 . 2NH_3 . \Theta_3 . 2N\Theta_2$, or rationally according to Blomstrand's views:

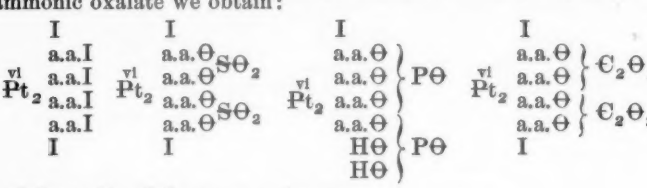
$$\begin{matrix} & \mathrm{I} & & \mathrm{I} & & \mathrm{Br} \\ & a.a.I & & a.a.\Theta.N\Theta_2 & & a.a.\Theta.N\Theta_2 \\ {}^{vi}Pt_2 & a.NH_2 & H_2\Theta\ {}^{vi}Pt_2 & a.NH_2 & H_2\Theta\ {}^{vi}Pt_2 & a.NH_2 \\ & a.NH_2 & & a.NH_2 & & a.NH_2 \\ & a.a.I & & a.a.\Theta.N\Theta_2 & & a.a.\Theta.N\Theta_2 \\ & \mathrm{I} & & \mathrm{I} & & \mathrm{Br} \end{matrix}$$

The unsaturated nitrates of the new platinum bases take up $H.\Theta.N\Theta_2$ directly, and give the saturated iodonitrate or bromonitrate:

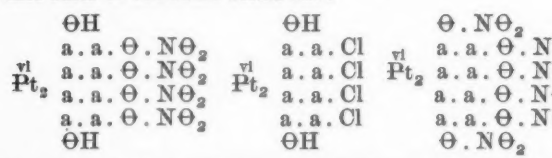
$$\begin{matrix} & \mathrm{I} \\ & a.a.\Theta.N\Theta_2 \\ {}^{vi}Pt_2 & a.a.\Theta.N\Theta_2 \\ & a.a.\Theta.N\Theta_2 \\ & a.a.\Theta.N\Theta_2 \\ & \mathrm{I} \end{matrix}$$

* In all these formulas a is the symbol for ammonia.

With iodide of potassium, sulphuric acid, sodic phosphate and ammonic oxalate we obtain:



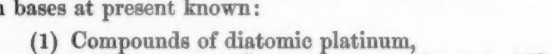
Other salts of the same series are:



The analogy between these compounds and those of hexatomic cobalt will be at once evident.

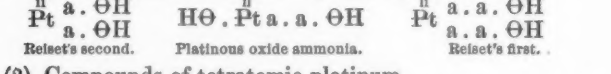
In conclusion, the author gives the following view of the platinum bases at present known:

(1) Compounds of diatomic platinum,



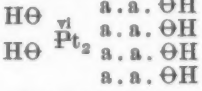
Reiset's second. Platinous oxide ammonia. Reiset's first.

(2) Compounds of tetratomic platinum,



Platinamine. Salt of platinoxide. Gros's base.

(3) Compounds of hexatomic platinum,



In these compounds ethylamine, aniline, and doubtless other organic alkaloids may replace ammonia to a greater or less extent. —*Berichte der Deutschen Chem. Gesellschaft*, iv *Jahrgang*, p. 70. (From a letter of C. W. Blomstrand.) W. G.

2. *On the preparation of hydric phosphide for lecture experiments.*—A. W. Hofmann has given a simple and elegant method of preparing pure hydric phosphide by means of iodide of phosphonium, PH_4I, which is itself easily prepared by the following process due to Baeyer. Dry carbonic disulphide is introduced into a tubulated retort, 100 gr. of phosphorus dissolved in it, and then 175 gr. iodine added in small portions at a time. The disulphide is then to be distilled off and the last traces removed by a current of dry carbonic dioxide, the retort being gently warmed. After cooling, the condenser is to be removed from the retort and

a long, wide and thin glass tube adapted to it, terminating in a gas tube which nearly reaches the surface of the water in a flask. 50 gr. of water are then to be poured in small portions at a time upon the iodide of phosphorus through a funnel tube drawn out at the end. Every time that water is added a violent reaction ensues and iodide of phosphonium condenses in the wide glass tube, while small quantities of iodhydric acid are condensed in the water of the flask. After all the water is added, the retort is at first gently warmed, and afterward heated to low redness so as to drive all the iodide into the glass tube. On breaking the glass tube after cooling, the iodide of phosphonium is found in thick crusts like sal-ammoniac, and with the quantities of material above mentioned amounts to about 120 gr. The iodide as thus prepared is mixed with small pieces of glass and introduced in pieces of the size of a pea into a flask provided with a rubber stopper, through which pass a funnel tube with a stop cock and bulb, and a delivery tube. If now a solution of caustic potash, of the strength of that commonly employed in organic analysis, be allowed to flow down upon the iodide, a regular current of hydric phosphide, PH_3, is evolved, which is completely under control. The gas is perfectly pure; 7·3 gr. of the iodide yield about one liter of gas. The gas is not spontaneously inflammable, but becomes so by passing through nitric acid which contains a trace of nitrous acid. Hofmann recommends as a beautiful lecture table experiment the decomposition of pure hydric phosphide by means of the induction spark passing between points of gas-carbon.—*Berichte der Deutschen Chem. Gesellschaft, Jahrgang* iv, p. 200. W. G.

3. *On the direct substitution of the alcohol radicals for the hydrogen in hydric phosphide.*—Absolute alcohol heated with iodide of phosphonium yields hydric phosphide, ethylic iodide and water. Hofmann has employed this reaction in a beautiful process for obtaining the iodides of triethyl and tetrethyl-phosphonium, which consists in simply heating one molecule of iodide of phosphonium with three molecules of absolute alcohol in a sealed tube for 6–8 hours at 180° C. Under these circumstances the ethylic iodide acts directly upon the hydric phosphide to form the iodides of the substituted phosphoniums. After cooling, the tube is found filled with a beautiful snow-white, crystalline mass, which dissolves in water to a perfectly colorless solution. The crystals are a mixture of about equal proportions of the iodides of triethyl and tetrethyl-phosphonium. A solution of sodic hydrate separates triethyl-phosphine as a colorless layer of liquid. The solution then gives, on evaporation, beautiful crystals of the iodide of tetrethyl-phosphonium; the triethyl-phosphine as separated by means of a funnel is chemically pure. The iodides of trimethyl and tetramethyl-phosphonium were easily prepared by the same process. In like manner allylic alcohol, phenol and glycerin gave promise of a rich harvest of new results.—*Berichte der Deutschen Chem. Gesellschaft*, iv *Jahrgang*, p. 205. W. G.

4. *On a new mode of formation of Para-oxybenzoic Acid;* by IRA REMSEN, Assistant in the Chemical Laboratory at Tübingen. (Communicated for this Journal.)—A short time since Barth* showed that by fusing sulphobenzoate of potassium with caustic potash oxybenzoic acid is formed. Subsequently Heintz† employed this reaction for the purpose of preparing oxybenzoic acid in larger quantity. The fact appears however to have escaped the notice of these chemists, that under the given circumstances paraoxybenzoic acid is likewise always formed, together with oxybenzoic acid, at times even in very considerable quantity.

I was occupied, according to the prescribed directions, in the preparation of oxybenzoic acid, which I required in an absolutely pure condition. On dissolving the first product in water, however, and allowing to crystallize, I was astonished to find that, as the solution cooled, somewhat discolored though well formed crystals, which presented the general appearance of paraoxybenzoic acid, were deposited. Recrystallized from water, these crystals became perfectly colorless and translucent. They were also more perfectly developed than at first, and the crystalline form, as well as could be determined without the aid of measurements, was identical with that of paraoxybenzoic acid. On subjecting this substance to a closer examination, its identity with paraoxybenzoic acid soon became evident. Dried at 100° the crystals became white and opaque from loss of water of crystallization. They fused at exactly 210°, and became solid at 165°. Heated above the fusing point they soon underwent decomposition. The perfect correspondence of these properties with those of paraoxybenzoic acid proves the identity beyond a doubt. The mother liquor from the first crystals yielded on evaporation a mixture, consisting of oxybenzoic and paraoxybenzoic acid, which, although crystallized out together could very readily be distinguished from each other. The latter presented itself, as usual, in the form of well developed crystals, and upon these the oxybenzoic acid had been deposited in the peculiar crystalline masses in which it is generally observed. In this case about equal quantities of the two acids had been generated.

It must be mentioned that the sulphobenzoic acid made use of in this experiment was prepared according to a method somewhat different from that usually employed. The vapors of sulphuric anhydride were conducted into a flask containing crystallized benzoic acid. As, however, after a space of time the benzoic acid became packed together in tenacious lumps, and thus resisted the further action of the anhydride, a small amount of fuming sulphuric acid was added to the mass, and the whole gently heated for a short time. On now diluting with water no benzoic acid separated.

It appeared to me possible that the method of preparation might exert an influence upon the nature of the resulting product. Hence I prepared sulphobenzoic acid according to the method

* Ann. de Chemie u. Pharm., cxlviii, 30. † Ibid., cliii, 326.

described by Barth in his article (i. e. by the action of sulphuric anhydride upon fused and pulverized benzoic acid), and tried the same experiment with the potassium salt of this acid. The only difference that made itself evident in the result was that less paraoxybenzoic acid was present in the product than in the former case, though by no means an inconsiderable quantity.

Finally, I subjected to the same process sulphobenzoic acid, that was prepared by simply heating benzoic acid with weak fuming sulphuric acid, and found that also in this case a mixture results, as was to be expected after the two previous experiments.

The two acids cannot be separated by means of partial crystallization. If the aqueous solution was not too dilute, the first portion that crystallized out contained, in the two last cases, the greater part of the oxybenzoic acid probably mixed with a little paraoxybenzoic acid. On evaporating the mother liquor further, about equal parts of the two acids crystallized out. The crystals of paraoxybenzoic acid could now be partially sorted out, and thus separated from the accompanying acid.

The preparation of the basic barium salt of paraoxybenzoic acid furnishes a means for an imperfect separation. This salt, as was shown by Barth,* is difficultly soluble in water, and is precipitated when baryta water is added to a solution of the neutral salt, whereas by this means no basic salt of oxybenzoic acid is produced. In this way a portion of the paraoxybenzoic acid can be obtained in a pure condition. There always remains a sufficient quantity of the salt in solution, however, to render the oxybenzoic acid useless for decisive experiments.

An attempt to employ the different properties of the cadmium salts of the two acids for the purpose of separation led to no favorable result.

It follows from the above experiments, that for the preparation of *pure* oxybenzoic acid, *crude* sulphobenzoic acid cannot be employed. It will be necessary to subject it to some process of purification. The simplest means that presents itself for this purpose is the preparation of the acid barium salt.

I am at present occupied in endeavoring to isolate and learn the properties of the sulpho-acid, the formation of which is in all probability the prime cause of the formation of paraoxybenzoic acid, and to determine the most favorable conditions for its formation. I shall also more carefully study certain uncommon phenomena, which can possibly be traced back to this, that the fact above discussed has up to the present been overlooked.

Tübingen, Germany, March, 1871.

5. *New Spectroscopic Combination;* by P. A. Secchi. (In a letter to Prof. Silliman, dated Rome, April 19, 1871).—I have the honor to announce to you the discovery of a new spectroscopic combination, by the aid of which one can see the images of the spots and of the solar protuberances with the spectral lines all at once in the same field.

* Zeitschrift für Chemie, N. F., ii, 646.

This result is reached by two methods; 1st, by placing before the objective of the telescope, a prism as large as that which I employ for star spectra, say of six inches opening, and causing the colored image which is produced at the focus of the lens to fall upon the slit of the ordinary spectroscope.

2d. The other method, less costly, consists in placing a direct vision prism of a high dispersive power in the path of the luminous rays before they arrive at the focus, and over the slit of the common spectroscope.

By these two methods is obtained in the field of the spectroscope, the solar image formed of different colored shades, with their spectral lines, but very sharply defined with their spots and margins quite exact, so that the details of the spots can be examined as with a colored glass.

If the sun's limb falls near the line C, which as we have just said, is seen at the same time as the image of the sun's limb, we see the chromosphere and the prominences showing themselves as brilliant lines more or less elongated from the sun's limb, according to the height of the prominences. The narrower the slit the sharper the image of the spots.

Thus the protuberances are seen as brilliant lines, but their form is recognized only by linear sections as in the old method of Janssen. Nevertheless their height can be perfectly recognized and measured, by measuring the distance from where the line C becomes brilliant to that point on the sun's limb, which is upon the same normal to the limb. By opening the slit the form of the protuberances can also be recognized, but only with a loss of precision of definition. By a narrow slit the height and position of the protuberances can be recognized and measured with the greatest precision, and their position fixed with reference to the spots and faculæ, in a manner far more simple and certain than with the ordinary spectroscope.

If in a spot there is a jet of hydrogen, C is at once seen to become more brilliant or at least the darkness is diminished, and the lines of calcium and of iron become broader, &c., as in ordinary observations, but with far greater satisfaction and certainty of position.

I have observed the spectrum of the little comet of Winnecke, and I have found a band in the green similar to that in the other comets.

6. *Lessons in Elementary Physics;* by Balfour Stewart, L.L.D., F.R.S., Professor of Natural Philosophy, Owens College, Manchester. London, (Macmillan & Co.). 1870.—This little work is by no means the common-place, second hand compilation that elementary books so often are, but a careful and thorough digest of the facts and principles of Physics, by one not only a master of his subject, but himself an original investigator. Its characteristic excellence is, that it exhibits in a compact, yet elementary form the freshest aspects of physical science, particularly as related to the doctrine of energy, so successfully developed within a few

years by the labors of Thompson, Rankine, Mayer, Clausius, and others. This doctrine runs consistently through the work, and lies at the basis of the explanations of the most important phenomena of heat, sound, light, electricity, etc. Indeed this little book is one of the best elementary expositions within our knowledge of the modern views respecting energy and its transformations, and we can heartily commend it to the attention of teachers, and of all who desire, in a small compass, a clear and consistent exhibition of the outlines of modern physical science.

II. Geology and Natural History.

1. *Lesquereux on Illinois Coal Plants, in the 4th vol. of the Report of the Geological Survey of Illinois.*—In the closing portion of Mr. Lesquereux's report on the Illinois coal-plants, the author treats of the larger groups here represented, and, while finding evidence against the existence of *Fungi* and *Lichens*, acknowledges the presence of *Conifers* (recognized by leaves and fruit, though not by woody fiber), besides the abundant *Equisetaceæ*, *Filices* and *Lycopodiaceæ*. He argues strongly for the uniformity, in character of vegetation, of the high and low land of the Carboniferous period, and concludes that there is no reason to believe that any prominent types existed which are not found in or near the coal beds. While denying that any remains of *Algæ* occur in or immediately over the beds of coal, he acknowledges their presence in sandstones and limestones near the base of the Coal-measures, both in Pennsylvania and in Indiana. His language implies what we learn to be true, that he had not seen the specimens of *Caulerpites* from Vermillion and Edgar counties of Illinois, mentioned in Prof. Bradley's reports on those counties, in the very volume under review, as occurring in a sandstone above the horizon of Coal No. 7, or at least as high as the middle of the Coal-measures. Similar forms were reported by G. C. Broadhead from the Missouri measures, though here again from the very base of the series. (See Tr. Ac. St. Louis, ii, 329, 1865.) S. W. Ely of Cincinnati also reports them from the Cumberland table-land; though, because of their character, he refers them to Devonian rocks, which do not exist there. Their position in the measures is in this case uncertain, though probably low. A locality in Indiana, not mentioned by Mr. Lesquereux, is in a heavy bed of sandstone outcropping along the bank of the Ohio river, a few miles below Cannelton.

Finding, in the ironstone nodules of Mazon creek and similar localities, various organs and parts of plants not elsewhere recognized, the author attributes their preservation to their mode of fossilization, implying that, in the softer rocks, these more delicate tissues perished before the rocks were solidified. We are more inclined to believe that their apparent absence from such beds is due merely to the greater difficulty of separating the rock from any but the broader and smoother surfaces.

"Besides two of the species described in the genus *Staphylopteris*," which has the fruit in a raceme on a separate stalk, "we have, in nodules from Mazon creek, seven fruiting species of *Alethopteris*, six of *Pecopteris*, and one *Asterocarpus*." Many others show the fruit-dots, through the tissue of the fronds, too indistinctly to be accurately made out—indicating "a proportion of fruiting branches [fronds] nearly as marked as it would be in collecting ferns of our time in a given area." *Neuropteris*, though plainly an herbaceous genus, and most beautifully and perfectly preserved, at many localities, and in great numbers, has not shown its fruiting.

Rhizomas of fossil ferns have been very rare; but we here find reported "numerous specimens of eight species." "It is therefore apparent that the organs of the ferns of the Carboniferous period were the same and in the same proportion as those of our times." "The roots of *Lepidodendron* are unknown as yet; and I believe that some species of this genus heretofore considered as branches of trees are mere creeping stems which, in some circumstances only, bear flowering stems or true *Lepidodendra*. It is the same with *Sigillaria*, the species of which I consider as fruiting stems of *Stigmaria*." "Remains of *Stigmaria* fill whole banks of fire-clay * * to a thickness of from six to fifty feet; and no remains of *Sigillaria* have ever been found in this clay in connection with them. Roots cannot live by themselves, independent of any other kind of organs, and it is certainly impossible to explain the mode of vegetation, the form, the nature of the *Stigmaria* and its action, in considering it as a root. But admitting these plants to be the floating stems of species of *Sigillaria* to which they have been sometimes seen attached, their peculiar nature and mode of vegetation become explainable, and in circumstances where they are found in the Coal-measures, they are in perfect harmony with the general vegetation of that epoch, as well as with the end which they were called to achieve. As is the case especially with our floating mosses, these floating stems of the Carboniferous epoch have the characters blended in a kind of uniformity which renders them scarcely recognizable. All the *Stigmaria* bear the same kind of cylindrical, bladdery leaves, and therefore have all, though belonging to different species, the same kind of cicatrices upon their stems, viz. a circular, double ring, with a single vascular scar in the center."

"It is evident that species of *Sigillaria* have sometimes grown in sand; and I believe that, under such circumstances, their subterranean divisions have somewhat modified their form, and have become similar to roots."

"Botanical palæontology is a peculiar science. It offers to its adepts mere fragments of organs, whose relation to a whole is mostly unknown, forcing him either to generalize and to consider in one species a number of organs which evidently pertain to plants of various kinds, or to specify and to divide under divers genera and species fragments which, if not evidently, at least often apparently, belong to the same vegetable. It is not surprising that

opinions concerning these remains are often at variance and often modified, or that the student of these fossil remains becomes discouraged by the sterility of his researches."

"European palæontologists, who have especially studied the fossil plants of the Carboniferous strata, Brongniart, Göppert, Schimper, Geinitz, etc., have admitted that the distribution of these plants is modified according to the age of each bed of coal, and that, therefore, the horizontal position of the coal strata may be recognized by species peculiar to each. These views, as it now appears,* have been advanced on theoretical ground, or are based on local observations which cannot be considered as furnishing conclusive proofs; for local modifications in the succession of species of plants may be the result of mere local atmospheric or geographical changes which do not affect the characters of the whole flora, and therefore the comparative distribution of the fossil species of plants of an epoch cannot be ascertained but from the examination of this flora over the whole extent of its domain."

The author is not prepared to abandon the theory of the "stratigraphical distribution of the fossil plants of the coal," because, first, "in a theoretical point of view, it is scarcely admissible" that throughout the long succession of alternating conditions evidenced by the Coal-measures "the flora has been represented by the same species distributed in the same proportion;" and, secondly, "the fossil plants hitherto obtained are mainly the results of local researches too limited to serve as a basis for general conclusions." When more extended examinations and complete collections have been made, "we shall have sufficient proofs of a gradual change in the characters of the vegetation of the Coal-measures from the first appearance of land vegetation."

The *Lycopodia*, beginning in the Devonian "by the number of species and size of trees," attain their full development near the base of the Coal-measures, and then decrease in numbers, though very slightly in size, to Coal No. 5 of the Illinois valley section, above which "*Lepidodendra* have not as yet been found."

"From horizons above the Pittsburgh coal we know nothing as yet of the flora of our Coal-measures." But Göppert finds *Lepidodendron* as high as "the lowest strata of the Permian" in Europe.

"The fruits described under the generic names of *Trigonocarpus*, *Rhabdocarpus* and *Ptilocarpus*, have as yet been found only from the Sub-conglomerate coal strata upward to Coal No. 2. They abound in the millstone grit and the hearth sandstone as in the shale of Coal No. 2. A few fruits of uncertain affinity, and considered under the name of *Carpolithes*, have been observed higher in the measures. As yet these cases are very rare."

Of *Neuropteris* some species range from bottom to top of the measures; while others, especially those of coarse or thick nervation or texture, are characteristic of the lowest seams. *Odontopteris* runs "up to Coal No. 2" and to Coal No. 6, as is stated on page 253 of the same volume. "Large thick-leaved species of

* From the authority of Prof. Brongniart, in letters, 1869.

Alethopteris, with *Callipteris Sullivanti*, are said to characterize Coal No. 2. *Sphenopteris* is considered "peculiar to the lower Coal-measures." "As representative of the higher coal strata of Illinois, there is no particular species to quote." "In the anthracite region of Pennsylvania, the highest strata are recognized by the presence of *Pecopteris arborescens*, which has not been as yet positively discovered in Illinois. * * In Europe it ascends to the Permian."

As the *Lycopodia* decreased in numbers and in size, they were "proportionally replaced by ferns."

The relation of the Coal-measures of Illinois to those of Pennsylvania, Rhode Island and Nova Scotia is indicated by the identity of numerous species of ferns. Of the common species of our eastern coal-fields, only one has not yet been found in Illinois. As regards the relation of these beds to the coals of Europe "no genus of our coal flora, except perhaps *Calamites*, can be considered as represented on both continents by species all identical or closely allied. As these points of difference, like those of affinity, have been observed from the beginning of the researches on the coal flora, and have not varied much in comparative quantity, they appear to fully corroborate the statement that, at the Carboniferous epoch, the flora which formed the constituents of the coal was, in Europe and in the United States, as different and at the same time as relatively alike, as is now the flora of the peat bogs of the two continents." F. H. B.

2. *On some points connected with the Cretaceous and Tertiary of North Carolina;* by T. A. CONRAD. (From a letter to J. D. Dana, dated Greeville, Pitt Co., North Carolina.)—I have been labelling the collection of fossils at Raleigh, and am now here exploring the marl pits and bank of Tar river. I have heard so much of the mixture of Miocene and Cretaceous fossils, that I was delighted to have an opportunity to see the beds where it occurs. I thought you would like to have a sketch of them. They run from three to five feet deep, and indicate the proximity of a Cretaceous shore, not an Eocene one, for we find only Greensand fossils, and they are extremely rare. The marl is fine sand, mixed with gravel and a profusion of broken shells, some water worn, having evidently been rolled in the surf; but among these fragments is a multitude of entire bivalves and univalves not in the least abraded. In company with Col. Yellowby of this place I was walking over a marl heap, when he picked out of the marl a horse-tooth, which I think is Leidy's *E. fraternus*. Lying on the top of the marl, it had evidently been thrown up from the lower part of the bed, and is black and mineralized. From the numbers which have been found in similar situations I am forced to conclude that the horse was a Miocene quadruped; and if this tooth should prove to have belonged to *E. fraternus*, it will fix the date of the Pea-shore clay near Philadelphia. Prof. Kerr has a new *Busycon*, eight inches long, which connects the two genera *Busycon* and *Sycotypus*, for it would belong to the latter if it had a distinct

canal at the sutures, but it has only a depression there. He has also a Mastodon jaw with two teeth on each side and two straight tusks projecting from the lower jaw. This, although found on top of the marl, I believe to have been a Miocene species, drifted on the marl by the rush of waters at the close of the period.

In the drift over the marl among sand and gravel on the shore of Tar river are great numbers of shark teeth, water-worn, mixed with water-worn fragments of friable granite. There is no material variation of the beds from those of New Jersey and Maryland by which a doubt of their synchronous deposition could be sustained, and a very few species are so like the recent ones that they might pass for the same. The same colossal Pectens abound as in Virginia, only the *P. Madisonius* so abundant in Virginia and Maryland is replaced by *P. Jeffersonius* and *P. septenarius*, five or six inches in width.

At Col. Yellowby's marl pit where digging is now in progress, I found the Miocene about three or four feet in thickness, resting on black Cretaceous sand with black gravel, and containing characteristic Ripley group fossils. It is here that a profusion of Belemnites is thrown up by the laborers, over the Miocene marl heap, and give rise to the opinion that they occur in the Miocene marl.

At Snow Hill, twenty-two miles from here in Green county, the Ripley Group is finely developed, containing closely packed specimens of the Ripley species in perfect preservation.

3. *On the Earthquake at Oahu, Hawaian Islands, on Feb.* 18; by Professor W. D. ALEXANDER. (From a letter to J. D. Dana, dated Oahu College, Feb. 28, 1871.)—I herewith send you some copies of our island papers containing accounts of a severe earthquake, which was experienced here on the 19th of this month. It was the severest earthquake ever experienced on the island of Oahu within the memory of man. In fact it was quite as severe here as on Hawaii, and seems to have been felt most severely at Lahaina. As I am not quite satisfied with the accounts of it published here, I will add a few facts that I have collected.

In regard to the *time*, Flitner's astronomical clock stopped at $10^h\ 11^m\ 17^s$ P. M., Honolulu mean time, allowing for the error of the clock. In regard to the *duration* of the shock, Rev. G. Williamson, Dr. J. Hutchinson, Judge Hartwell and one or two others who timed it carefully, agree within a few seconds in making it 55 seconds. The general opinion here is that it lasted about a minute, and the same was the case at Lahaina and Hilo.

In regard to the direction of the shock, the motion was chiefly vertical with a rocking movement northeast and southwest. It was compared by some to the sensation of riding a "bucking mustang" or driving a cart over a rough corduroy road. Many stone and adobie buildings were badly cracked, particularly our school house, the large stone church, the Queen's hospital, and the court house, and the northeast and southwest walls were generally most shaken. Stone fences running northwest and southeast were thrown down, while those at right angles to this direction

were not injured. Doors facing southwest were swung open, and hanging lamps were left swinging for ten or fifteen minutes in almost every instance in the same direction, viz. from northeast to southwest. Considerable crockery was broken, and heavy articles of furniture displaced. The usual roaring sound preceded this earthquake. Persons who were on board ships in the harbor report that they heard this terrible roaring sound far out at sea, and then the ships that lay farthest out were first struck and afterward those that lay at the wharves. They agree that the vessels were first drawn violently out to sea and then in the opposite direction.

Several persons of undoubted veracity insist that they saw a flash of light on Punchbowl hill the moment before the earthquake commenced. At Waialua at the north end of this island the shock was comparatively slight. At Waianae on the N. W. of this island, the earthquake was severe. Quite a landslip took place, carrying a house several rods. At Koolau, milk was thrown out of pans east and west. The schooner Annie in the channel south of Lanai was terribly shaken, and her bulwarks split amidships.

At Lahaina, as you will see by the papers, the shock was more severe than here, the ground cracked open in many places, and all the stone or adobie houses in the town were badly damaged. Rev. S. E. Bishop of Lahainaluna Seminary gives the time as $10^h\ 15^m$ P. M. The direction of the vibration was from south to north, or according to some from S.E. to N.W.

At Molokai the shock was severe, especially at the western end. The road up the great *pali* of Kalaupapa on the north side was rendered impassable.

At Wailuku, on the east side of West Maui, the earthquake was much less severe, stone walls being thrown down in some places, but no serious damage done. The *time* by my father's clock, which is set by the sun, was $10^h\ 20^m$ P. M., equivalent to about $10^h\ 15^m$ Honolulu mean time. At Makawao on East Maui the shock was slight. At Capt. Makee's, on the S.W. side of Haleakala, it was much less severe than at Lahaina. A train of molasses kettles was displaced, which was about the only damage done. The earthquake along the west coast of Hawaii was almost simultaneous with that experienced here, and about equal to it in severity. From Kohala I learn that the shock seemed to come from the *west*, that some stone walls were shaken down, but the stone church and plantation chimney remained uninjured. We hear the same story from Waimea and Kawaihae. From *Kona*, Mr. Parke writes, that the time of the shock was $10^h\ 5^m$ by his watch (which is probably within five minutes of the true time), that stone walls were thrown down, but no great damage done. At *Hilo* the earthquake was much lighter. According to Judge Hitchcock it took place at $10^h\ 15^m$ P. M., and lasted a minute.

From *Kauai* I hear that it was severe at Koloa on the south side of the island, but less severe and light on the north side at

Hanalei. No earthquake wave of any consequence is reported from any quarter.

The phenomena seem to me to point to a center of disturbance to the leeward of the islands, perhaps at the center of the circle of which the islands form an arc, and at a great depth. But as you see, our *data* are as yet very imperfect. There have been several slight shocks felt here since, on the 22d and 24th. I cannot learn that there is any unusual action going on at Kilauea or in Mokuaweoweo.

I am hoping to commence the survey of these islands next May.

4. *Note on Trimerella acuminata ;* by E. BILLINGS. (Communicated by the author).—The genus *Trimerella* was founded by me on two species, *T. grandis* and *T. acuminata ;* but of the latter I had only the rostral half of the ventral valve of a small specimen. I therefore named it provisionally and stated that it differed "from *T. grandis* in having the spiral extremity much more pointed, and the longitudinal septa running all the way to the beak." (The septa here alluded to and the walls between the tubes mentioned below). Within the last few days Mr. T. C. Weston, of our survey, discovered several new specimens, among which are two exhibiting the casts of both valves in connection. It then immediately became evident that several separate dorsal valves in our collection belonged to the same species. I have, therefore, now abundant material to illustrate the species, which I shall do soon, but in the meantime propose to notice its leading characters briefly.

The ventral valve, in young specimens, is somewhat straight along the median line, but becomes more and more arched as the size increases. It is ovate, rounded in front, widest a little in advance of the mid-length, thence tapering with nearly straight sides to the beak which is narrowly rounded,—almost acute. In the substance of the shell there are two large tubes, which extend from about the mid-length to the beak. These are joined in the beak by two others, one on each side. All of these tubes are open anteriorly, but closed at their terminations in the beak. The area is large, concave and transversely striated. The dorsal valve is much shorter than the ventral, more convex and has its beak very strongly incurved. It has two tubes which extend nearly to the apex of the beak. The shell is marked with coarse concentric accretion ridges of growth. Length of the largest specimen 3½ inches, width 3 inches. The above is sufficient to show that this species is quite distinct from *T. grandis.* If a section were to be made across the beak of a perfect shell of *T. acuminata*, it would show four perforations arranged in a curve, exactly as in the similar section of the Swedish species figured by Dr. Lindström. But if the beak of *T. grandis* were to be cut across, it would show only two orifices, and they would be the homologues of the two lateral perforations in the section of *T. acuminata*, because in *T. grandis* the two central tubes do not extend into the beak, but terminate before they reach it.

Montreal, May 5th, 1871.

5. *Note on the discovery of the opercula of Hyolithes in New York;* by S. W. FORD. (Communicated by the author).—Several weeks ago, being in Montreal, I showed Mr. Billings, Paleontologist of the Geological Survey of Canada, a small collection of fossils that I had made in the Primordial rocks near this place. He pointed out to me, that among them there were the opercula of two species of *Hyolithes.* One is a minute circular species with four pairs of lateral muscular impressions, and two smaller, dorsal, all radiating from a point near one side. The other species is larger and like a *Discina* on the outside. Mr. B. showed me several specimens of the smaller species, that had been collected by Mr. T. C. Weston of the Canadian Survey last summer, in rocks of the same age below Quebec. I am informed that this is the first discovery of the opercula of *Hyolithes* yet made on this continent. I have made some observations on the rocks of this vicinity, and collected a number of species of fossils, of which I hope to give an account at an early date.

Troy, May 8th, 1871.

6. *Note on a new and gigantic Species of Pterodactyle;* by O. C. MARSH.—In addition to the Cretaceous fossils described pp. 447–453, the Yale College party obtained several specimens which indicate a huge flying reptile, apparently of the genus *Pterodactylus.* The remains belonged to two or more individuals. They are fragmentary, but some of them are quite characteristic. The distal ends of two long bones, similar in form to the tibia of a bird, are evidently portions of the peculiar metacarpal of the wing-finger. One of these, which retains the lower part of the shaft, resembles in its proportions the corresponding bone in *Pterodactylus Suevicus.* The condyles are well developed, and have a sweep of two thirds of a circle. They appear to have been originally somewhat oblique. In size and general form, they are not unlike those of the specimen figured by Owen in his Memoir on Cretaceous Reptiles, 1851 (Sup. I, Pl. IV, fig. 9–11), but there was apparently no longitudinal elevation between them. The shaft, where broken, is subtrihedral, with the posterior face concave. The bones are light, with thin compact walls. The long bones are pneumatic. The teeth are smooth, and compressed. The length of the metacarpal with the part of the shaft preserved is six and one-half inches; the fore and aft extent of the condyles fourteen lines; the transverse extent about thirteen lines. This would indicate an expanse of wings of not less than twenty feet! The species, which is the first found in this country, may be named *Pterodactylus Oweni*, in honor of Professor Richard Owen, of London. The remains now representing it were discovered by the writer, in November last, in the upper Cretaceous formation of Western Kansas.

7. *Earthquakes—Subterranean electrical disturbances.*—A few minutes before and after the earthquakes of the 17th March last powerful positive electrical currents were rushing toward England through the two Anglo-American telegraph cables, which are broken near Trinity Bay, Newfoundland. Mr. C. F. Varley, C.E., who informed us of the fact, broaches the novel speculation that some earthquakes may be due to subterranean lightning.–*Nature*, Apr. 20.

8. *Geology of Louisiana.*—The Annual Report of the Board of Supervisors of the Louisiana State University for the year ending Dec. 31, 1870, and session of 1871, contains the Second Annual Report of the Geological Survey of Louisiana to the General Assembly (of the State), by Prof. F. V. HOPKINS. It gives a brief account of the geological formations—which do not reach back in time beyond the Cretaceous, and are almost wholly Quaternary and Tertiary—and is accompanied by a colored geological map of the State. Lists of fossils of the beds are given after determinations of the species by Prof. E. W. Hilgard of the Mississippi University.

9. *Preliminary Report of the U. S. Geological Survey of Wyoming and portions of contiguous territories* (being a Second Annual Report of Progress); conducted, under the authority of the Secretary of the Interior, by F. V. HAYDEN, U. S. Geologist. 512 pp. 8vo. Washington, 1871.—Dr. Hayden during the past year continued the survey of the preceding season, by investigations from Cheyenne to Fort Fetterman, South Pass, Fort Bridger, the Uintah Mountains, Henry's Fork, Green River Station on the Union Pacific Railroad, and back, and obtained important results. In the lower range of hills which extend up to the South Pass on the south side of the Sweet Water, there was a limited area of granite with overlying Potsdam sandstone containing *Obolella nana* and a *Lingula.* Many fossil shells, vertebrates and plants were collected, which are described in special reports appended to the volume severally by F. B. Meek, Dr. J. Leidy, Prof. E. D. Cope, and Mr. Lesquereux, adding very much to the value of the volume. There is also an excellent report on the Tertiary coals of the West by Jas. T. Hodge, another on the ancient lakes of Western America by Prof. J. S. Newberry, and finally, a report on the industrial resources of Western Kansas and Eastern Colorado by Mr. R. S. Elliott.

10. *Lehrbuch der physikalischen Mineralogie;* von Dr. ALBRECHT SCHRAUF. Vienna, 1868.—Dr. Schrauf, the able author of the Atlas of Crystalline forms of Minerals noticed on page 220, issued in 1866 and 1868 volumes I and II of a work on Physical Mineralogy, which is a thorough and profound treatise on descriptive and mathematical crystallography, and the optical, thermic, and other physical characters of minerals or inorganic substances. We learn from the author that he has in preparation a third volume, which will be a companion to his Atlas of crystalline forms, and contain tables of the dimensions and angles of the crystals of the various mineral species, supplying all that is needed to make the atlas a complete exhibition of mineral crystallography.

10. *Mineralogische Notizen,* von F. HESSENBERG. No. 10 (Neunte Fortsetzunge) with 3 plates of crystalline forms. Frankfort on the Maine 1871.

III. Astronomy.

1. *On a Sunspot seen with the Naked Eye;* by Francis H. Smith. (Editorial corresp. dated University of Virginia, Apr. 19, 1871.)—On Friday, the 14th inst, shortly before sunset, I saw, with the naked eye, a large sunspot just above and to the left of the center of the disc. The atmosphere was quite hazy at the time, and one could gaze with impunity upon the sun, which appeared of a bright orange color. The spot came out with remarkable distinctness; as thin horizontal streaks of darker haze passed over the disc, Prof. Peters, who was with me at the time, saw the spot plainly.

Under the same circumstances of position, haze and color, Col. Venable and myself obtained a distinct view of apparently the same spot, which had moved in the interval to the right of the sun's center. The color of the latter was such, that a light blue glass rendered it almost invisible.

I tried in vain earlier in the day, when the sun was nearer the meridian, to detect a spot on it by looking through colored glasses.

Some time after the first occasion mentioned, I examined the sun with a small refracting telescope, and thought there appeared near the indicated position a large spot, with a smaller companion, yet in the absence of micrometric measurement, I would not have thought it large enough to be visible to the naked eye.

2. *Discovery of a new Planet.*—The 113th asteroid has been discovered by Dr. Luther at Bilk. It is of the 11th magnitude and has received the name *Amalthea.*

3. The following *table of the twenty-five small planets previously discovered* may be useful for reference.

No.	Name.	Time of discovery.	Discoverer.	Mean dist.	Angle of Eccent.		Incl.		Long. of node.		Long. per.	
					°	′	°	′	°	′	°	′
88	Thisbe,	June 15, 1866.	Peters.	2·7659	9	28	5	15	277	47	308	33
89	Julia,	Aug. 6, "	At Marseilles.	2·5505	10	22	16	12	311	33	353	14
90	Antiope,	Oct. 1, "	Luther.	3·1368	9	57	2	17	71	20	301	59
91	Aegina,	Nov. 5, "	Borelli.	2·4917	3	47	2	10	11	42	68	54
92	Undina,	July 7, 1867.	Peters.	3·1846	5	52	9	57	102	45	331	13
93	Minerva,	Aug. 24, "	Watson.	2·7536	8	5	8	37	5	4	275	1
94	Aurora,	Sept. 6, "	Watson.	3·1615	5	2	8	5	4	34	45	22
95	Arethusa,	Nov. 23, "	Luther.	3·0712	8	28	12	51	244	22	30	9
96	Aegle,	Feb. 17, 1868.	Coggia.	3·0543	8	4	16	7	322	51	164	17
97	Clotho,	Feb. 17, "	Tempel.	2·6694	14	56	11	45	160	36	65	46
98	Ianthe,	Apr. 18, "	Peters.	2·6845	10	54	15	33	354	18	147	45
99	Dike,	May 28, "	Borelli.	2·8339	14	3	14	1	41	35	239	9
100	Hecate,	July 11, "	Watson.	3·0964	9	0	6	22	128	27	307	50
101	Helena,	Aug. 15, "	Watson.	2·5731	8	1	10	4	343	35	328	41
102	Miriam,	Aug. 22, "	Peters.	2·6609	14	47	5	5	211	37	354	41
103	Hera,	Sept. 7, "	Watson.	2·7029	4	39	5	24	136	18	321	57
104	Clymene,	Sept. 13, "	Watson.	3·1798	11	23	2	53	43	47	62	12
105	Artemis,	Sept. 16, "	Watson.	2·3799	10	9	21	39	187	54	242	36
106	Dione,	Oct. 10, "	Watson.	3·1623	10	33	4	39	63	15	27	13
107	Camilla,	Nov. 17, "	Pogson.									
108	Hecuba,	Apr. 2, 1869.	Luther.	3·2134	5	46	4	24	352	20	175	4
109	Felicitas,	Oct. 9, "	Peters.	2·6941	17	27	8	3	4	56	55	56
110	Lydia,	Apr. 19, 1870.	Borelli.	2·6931	4	37	6	0	57	4	357	28
111	Ate,	Aug. 14, "	Peters.	2·5756	5	49	5	1	306	26	122	53
112	Iphigenia,	Sept. 19, "	Peters.	2·4357	7	16	2	37	324	5	337	43

It will be seen that of these twenty-five planets, fifteen were discovered in this country, six in France, four in Germany and one in India. H. A. N.

IV. Botany.

1. *Flora Brasiliensis.*—Part 50 of the great work of Martius, continued by Eichler, was issued at the close of the last year. It is occupied by Mr. Bentham's continuation of the *Leguminosæ* (viz. *Swartzieæ* and *Cæsalpineæ*), in 254 pages of letter-press, fully illustrated by 66 plates. The *Swartzieæ* form now only the ultimate tribe of *Papilionaceæ*. Among the figures are to be found one of *Guilandina Bonducella* and of a related species, now reduced to *Cæsalpinia*, of *Parkinsonia aculeata*, and of *Cassia Chamæcrista*. There are 189 Brazilian species of *Cassia*,—no small part of the genus, the much desired monograph of which, prepared two years ago by Mr. Bentham, is probably now in press. A. G.

2. *Popular Names of British Plants.*—Dr. Prior has brought out a second edition (Williams & Norgate, 1870) of this very interesting volume, with many additions or emendations. It is a treasury of curious lore, philological, antiquarian, and botanical, by one thoroughly fitted on every side for the handling of these topics. An alphabetical list of the systematic names of those British plants which have popular appellations is annexed, and under which these are enumerated. A notice of the first edition was published in this Journal, for May, 1864. One can hardly resist the temptation to make extracts from the more curious articles. A. G.

3. *Les Fleurs de Pleine Terre*, etc., par Vilmorin-Andrieux (Paris, 1870), which in the midst of terrible times has passed to a third edition, now rivals in bulk the portly *Bon Jardinier*, filling as it does 1563 duodecimo pages, illustrated by 1300 wood engravings. These, moreover, are separately issued in an *Atlas des Fleurs*, and of this an edition in English is published, forming a handsome and very useful volume. The miniature representations, sometimes of a blossom or flowering branch, commonly of the whole plant, exhibiting its port, are wonderfully effective. A. G.

4. *A Synopsis of all the known Lilies*, by Mr. Baker, one of the assistant botanists at Kew, and author of an important paper on *Liliaceæ* which was recently noticed in this Journal, is in course of publication in the Gardeners' Chronicle, London. This standard horticultural periodical, we may remark, keeps up well its scientific character, and has many interesting botanical articles and memoranda. A. G.

5. *On the Forms and Distribution over the World of the Batrachium section of Ranunculus;* by W. P. Hiern, M.A. Reprinted and revised from the Journal of Botany, 1871. With two plates.—An unusually thorough paper, maintaining the view that these plants, "considering the intricate network of connecting links that seem to break down specific characters in several di-

rections," are most philosophically regarded as forms of one aggregate species. The author adopts for this the name of *R. hydrocharis* Spenner (1829); but he certainly should have retained one of the Linnæan names, the most appropriate one of *R. aquatilis.* He proceeds to arrange and describe the *subspecific* forms, admitting 35, all but one of which bear old names. The exception is *R. Lobbii*, from California, one of the *hederaceus* group, and indicated as a variety of that species by Dr. Torrey in the Botany of Whipple's Expedition. The genuine *R. hederaceus* has recently been detected by the late Mr. Munn, near Norfolk, Virginia, in freshwater marshes, having all the appearance of being indigenous. Mr. Hiern states that it occurs in North America, but does not say where. A. G.

6. *The Rhododendron, and "American Plants;"* by EDWARD SPRAGUE RAND, Jr. Boston: Little, Brown & Co. 1871. pp. 187, 12mo.—One of those small and neat practical books, very handsomely printed, which are so attractive; and with reason, as conveying the information which the amateur cultivator needs, in a pleasant and readable form, free from all technicalities, and indeed from all scientific details. And the author writes not only *con amore*, but from abundant knowledge of Rhododendron lore and culture. So great is his success that he can affirm that Rhododendrons may be grown in New England "as easily as lilacs;" but, as subsequently qualified, only by those who will take the requisite pains in the first instance. A. G.

V. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Ventilation of Soldiers' Quarters. Special report of Acting Assistant Surgeon* B. F. CRAIG, *United States Army*—appendix to the Surgeon General's "Circular No. 4."—Dr. Craig has made a valuable contribution to our knowledge of the general subject of ventilation by his researches made at certain military posts, the details of which are given in his "Special Report" to General Barnes. We have compiled from this paper the accompanying tabular statement of Dr. Craig's results in a form convenient for reference. Dr. Craig places but little reliance on the determinations of animal matters emanating from the human body, seeing "they are so small in actual mass and of so complex and indefinite a character, that they evade to a certain extent the powers of chemical titration." He therefore confines himself chiefly to the determination of carbonic acid (Pettenkofer's method, modified slightly) and the measurements of hygroscopic moisture, temperature, &c.

The quantity of carbonic acid in air is increased about one hundred times in passing through the lungs, or from about four parts in 10,000 to four parts in one hundred of air. Mr. Edward Smith's experiments have shown that a sleeping man produces about four-tenths of a cubic foot of carbonic acid per hour, and will therefore increase the amount of it in 1000 cubic feet of air to

Tabular Statement of Experiments on Ventilation and Composition of Air in Military Barracks, made by Assistant Surgeon B. F. Craig, U. S. Army, prepared from his Report to Surgeon General Barnes.

Experiment.	Time of observation.	Tempt. Fh.		Grains moisture in 1 cubic ft. of		Apartment. Capacity in cubic ft.	Contents.			Estimation of CO_2 in 10,000 volumes of			Hourly ventilation per man in cubic ft.	Total hourly discharge of air in cubic ft.	Mode of ventilation adopted.
		Inner air.	Outer air.	Inner air.	Outer air.		Men.	Floor space pr. man.	Cubic ft. air per man.	Outer air.	Inner air.	Differ. = contamination.			
1	12.30 night, Oct. 5, '70.	69°	63°	----	----	Casemate, Fort Adams, 10,700 ft.	15	65	713	4·08	9·67	5·59	474	7,110	Open doors, &c., in summer, stove and flues in winter.
2	4 A. M., Oct. 6, '70.	----	----	----	----	Same apartment.	15	65	713	4·08	10·07	5·99	526	7,890	Same.
3	After midnight, Oct. 13–14.	70°	57°	4·62	3·56	Casement in Fort Independence, Boston, 3,927 ft.	9	39·61	436	3·68	7·18	3·50	997	8,973	Same.
4	After midnight, Oct. 14–15.	70°	52°·5	4·29	----	Casemate, Fort Warren, Boston, 8,100 ft.	11	49	540	5·49	6·26	0·77	4,950	54,450	Stove and open windows.
5	Same.	72°	52°·5	4·76	3·41	Do. do.	10	54	540	5·49	8·37	2·88	1,200	12,000	Similar.
6	No date.	59°·5	----	3·75	----	Casemate in Fort Wood, N. Y. harbor, 15,860 ft.	14	96	1,132	4·02	5·12	1·10	7,620	106,700	Fire.
7	No date.	58°	47°·5	4·02	3·29	Similar to 6.	40	33	396	4·62	9·13	4·51	767	30,700	No fire.
8	No date.	70°	47°	4·07	2·60	Frame barracks, Fort Wadsworth, 21,870 ft.	15	145	1458	4.23	6·24	2·01	1,514	22,710	3 chimneys and 2 fires.
9	No date.	----	----	----	----	Casemate, Fort Fort Hamilton, N. Y., 7,700 ft.	18	34	428	4·22	14·06	9·84	260	468	Useless.
10	----	----	----	----	----	Old frame barracks, Willett's Point.	28	58	780	2·96	4·96	1·90	780	21,640	Open slits at eaves and stoves.
11	----	----	----	----	----	Willett's Point. Similar to last.	11	----	1,500	----	10·67	----	25	275	Nothing.

the extent of four parts in 10,000, and in 2000 feet to the extent of two parts in 10,000, &c. So that from the percentage of carbonic acid we may infer, by computation, the number of cubic feet of fresh air received per hour for each man. Of course an allowance is to be made for the amount of air originally contained in the room, and this is to be determined on obvious principles, by considering the size of the room, the number of its occupants, and the length of time during which it had been occupied by them when the air was collected. Dr. Craig describes in detail the precautions taken by him to secure accuracy in the use of the methods of determination employed in his experiments, the results of which are condensed into the annexed table.

Dr. Craig's remarks with regard to the general results of his examinations, that the amount of air which writers on hygiene have held to be the minimum supply consistent with perfect healthfulness, viz. 2000 cubic feet per man per hour, was in most of the cases attained only in exceptional cases, while in some of the instances cited the deficiency is excessive.

The amount of good scientific work which has been undertaken and is still in progress in connection with the Surgeon General's office is highly creditable to the gentlemen in charge. The microscopic labors of Dr. Woodward in connection with the Army Medical Museum are already familiar to our readers. The enormous collections of morbid anatomy and surgery, preserved in the most methodical and orderly manner in the museum itself, are in process of description in many volumes of text with illustrations, parts of which are already issued. B. S.

2. *Reports of the United States Commissioners to the Paris Universal Exposition*, 1871. Published under the direction of the Secretary of State, by authority of the Senate of the United States; edited by Wm. P. Blake, Commissioner of the State of California.—Mention of the various reports included in this series has been made in this Journal, as they have appeared. They have recently been issued in six handsome octavo volumes. The reports, the work of many able authors, contain a large amount of valuable matter on a wide range of topics, and have been well edited by Mr. Blake. The first volume contains an index to all the reports.

3. *Associations for the Advancement of Science.*—The next meeting of the British Association opens at Edinburgh on August 2d, and of the American, at Indianapolis, Indiana, on August 17th. Prof. Wm. Thomson is president of the former, and Prof. Asa Gray, of the latter.

OBITUARY.

Charles Mayer Wetherill, Ph.D., M.D., died suddenly of heart disease, on the morning of March 5th, at his residence in the grounds of the Lehigh University, South Bethlehem, Pa.

Dr. Wetherill was born in Philadelphia, 4th Nov., 1825, where he graduated with first honors in the University of Penn., in 1845. In 1846 he worked at practical chemistry in the laboratory of Booth and Boyé, and during 1847 he passed eight months with

Pelouze in Paris. Thence he proceeded in Nov. 1847, to the then world-renowned teachings of Liebig, at Giessen, and there graduated Ph.D., in May, 1848. The years 1849–50–51–52, were spent in chemical investigations in his private laboratory in Philadelphia, and in giving courses of chemical lectures before the Franklin Institute. He subsequently held no public position until his election in July, 1862, to the position of chemist of the Agricultural Department of the Patent Office, which post he occupied until Oct., 1863. In 1866 he was elected to the chair of chemistry in the Lehigh University, which office he held at the time of his death.

Dr. Wetherill was a member of the American Philosophical Society, and of the Academy of Natural Sciences of Philadelphia, and of the Geological Society of Vienna. In 1853, the degree of M.D. was conferred upon him by the N. Y. Medical College.

A man of science, as such, writes his own eulogy in his works, in which alone will he live beyond the memory of his associates; and in the annals of American science Wetherill will be known when the names of many of greater temporary éclat will have been dropped from the records. He was essentially a man of work, and the list of his researches will show how honestly he devoted himself to his science, and strove—as all true men of science will strive,—to bring within the bounderies of the known, some of the extended region of possibilities and of conjectures. His title to such conquests will chiefly rest on his paper, "*Ueber neutrales schwefelsaures Aethyloxyd und dessen Zersetzungsproducte mit Wasser*," An. der Ch. und Pharm., lxvi, 117, and Proc. Amer. Phil. Soc., 1848, and in his "*Experiments with the Ammonium Amalgam*," Amer. Jour. Sci., 1865 and 1871.

Innately truthful as a man and conscientiously faithful in all he undertook, the body of his work will, we are bold to hope, stand the tests of the revision of more searching methods which will be added in the advance of knowledge. Another trait of Dr. Wetherill's character was a steady, systematic execution of his work, generally founded on plans which he had previously matured by viewing on all sides. He leaves in the Lehigh University laboratory a monument of himself, and no one can visit that institution and walk through those beautifully equipped rooms without seeing the mental characteristics which we have mentioned.

In his death science mourns the loss of a faithful servant, and friendship casts upon his grave this tribute,—in heartfelt recognition of his worth. A. M. M.

Herschel, the Astronomer, died on the 12th of May, at the age of seventy-three.

Becquerel.—M. Becquerel, who recently died in France, was not the physicist, but his son, Dumeril Becquerel.

Geological Survey of Canada; Alfred R. C. Selwyn, Director. Report of Progress from 1866 to 1869. 476 pp. 8vo, accompanied by Geological and Topographical maps. Montreal: Dawson Bros. (B. Westermann, New York).

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